POWER

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Swallowing the Camel

"I sent for you," said the manager, as the chief engineer seated himself, "to inquire about this item on your expense account—lunch, $1. Now we want to pay all legitimate charges, Hubbard, but I cannot remember any event in the past month which I can connect with this. Just what was the occasion?"

"There wasn't any occasion."

"What?" The manager's face flushed. "Then what is the meaning of this item?"

"I suppose," sighed the chief, "that I might as well confess, first as last, that I padded the account to that extent. I thought it might get by you."

The manager's eyes bulged, his cheeks puffed. "Hubbard I am surprised. Wh-wh-why—"

"Just a moment, Mr. Brown," broke in the chief with a gesture and a half smile that served to calm his majesty. "You shall know why. Only let me tell the tale in my own way. It may, at first, seem a roundabout way, but really it is not. I am going straight to the point. Now, our daily coal bill is about $600, isn't it? And upon that sizeable expenditure there is not one check. The expense account before you covers a whole month, and is for only $6. And that small account is carefully audited. Now, don't think I am criticizing that. I approve of it. It is the way to do. It is business. And you have just now discovered a leak, thereby. But do you suppose no leaks exist in the larger account? If I am careless or a grafter in a matter of six dollars, then you had better watch me closely when it comes to six hundred. But you don't do it."

The manager slowly blew out a cloud of smoke. He foresaw the recital of an old story. But this time it seemed to be presented in a novel manner, and the boldness of the plot rather appealed to him. He already saw the point, but he would listen it out.

"Six hundred dollars a day and not a check of any sort upon it. It isn't business. It ought to be interesting to see just where that $600 goes. It might be instructive. Perhaps there is a pad in this account, too. What if $50 worth of CO is going up the chimney? Perhaps $25 goes to heat excess air. Another $25 may be lost in low-temperature feed. And so on. The total loss might be $150. No one knows anything about it. I would like to know. We ought to know. We ought to have means to know. We ought to have coal scales and a feed-water meter. Then we can check up our evaporation. And we shall find that losses exist. Our plant is not perfect. No one realizes that better than I. Leaks there are, and the leaks should be located. For this we must have an Orsat and a CO_2 recorder, pyrometers and thermometers.

"Now that it has served its purpose, let's cancel that lunch charge. You caught me there. But if by indolence or mismanagement I were to lose $100 a day for you in the fireroom, you would be as wise to it as a new-born babe."

"Say, Hubbard, you scamp," the manager interrupted, "just make out requisitions for what you need, and I will see what I can do."

"I brought them with me," answered the chief, as he laid the papers on the desk. "I think I have included everything."

"I'll trust you for that," laughed the boss. "But I suppose I will have to check you up on it."

Contributed by WILLIAM E. DIXON, *Livermore Falls, Me.*

Small Centrifugal Blower of High Pressure

By Henry F. Schmidt

SYNOPSIS—A turbine and blower that ran at 60,000 r.p.m. with a blade speed for the turbine of 1,840 ft. per sec. and 2,100 ft. tip speed for the blower rotor. With a single row of turbine blades 8¼ in. diameter the turbine developed 400 hp. and the blower with a single rotor 8 in. in diameter delivered 1,360 cu.ft. of free air per minute against a pressure of 24 lb. The pull of one of the fan blades due to centrifugal force was over a ton.

Centrifugal blowers have generally been thought of as machines for handing large volumes of air against small pressures, until recently; in fact, 16 to 20 oz. was considered about the limit of pressure that could be created by a centrifugal type of machine. The following notes and illustrations of a blower developed by the Westinghouse Machine Co. will therefore be of interest. The writer believes this blower to have created the highest pressure ever obtained from a single-stage blower.

As the speed selected for the blower was 43,500 r.p.m. at normal pressure and it was desired to extend the tests to 60,000 r.p.m., it was necessary to design also a small turbine for driving the blower, as there is no means of transmitting the 350 to 400 hp. required to drive it to a shaft running at these speeds. For the sake of cheapness it was decided to make the turbine a simple impulse wheel with one row of moving blades, this being sufficient to abstract practically all the energy in the steam, as the blade speed was designed to be from 1,330 ft. per sec. at normal to 1,840 at the highest.

These very high speeds made it necessary to form the blades integral with the wheel, since the centrifugal forces become so great that no known method of blade attachment would suffice. Furthermore, it was found desirable to form the shaft in one piece with the disk as, of course, at these speeds it becomes impossible to design one with a hub that would have the required strength, and the shaft attachment to a solid disk becomes difficult as it increases the weight and length between the bearings and introduces a place where weakness may develop because of faulty workmanship and cause difficulties with the balance and running of the machine.

The same considerations in regard to design applied to the blower rotor, which was also constructed from one forging, the blades being formed by milling out the material between them. A designed tip speed of 1,520 ft. per sec. at normal speed and a maximum speed of 2,100 ft. per sec. of the blower rotor necessitated the use of high-grade forgings for both the turbine and blower rotors.

In ordering the material it was required that two test specimens be cut from each forging—one to be taken from the end of the shaft and the other from a piece cut out at right angles to the radius of the disk and midway between the center and the circumference. The material employed was a heat-treated chrome-vanadium-nickel steel, the elastic limit of which was specified to be not less than 110,000 lb. per sq.in., and the ultimate tensile strength not less than 145,000 lb. per sq.in. with a reduction in area of not less than 20 per cent. in 2 in. The test pieces cut from the forgings showed about 105,000 lb. per sq.in. elastic limit, but the elongation was a little higher than asked for, so they were accepted, as a good elongation is highly important, since it is the ability of the material to stretch which permits the construction of unsymmetrical rotors; without stretching of the metal, the elastic limit would be exceeded in many places and rupture would result.

In addition to using the best steel obtainable, the high speeds involved required the greatest care in the design

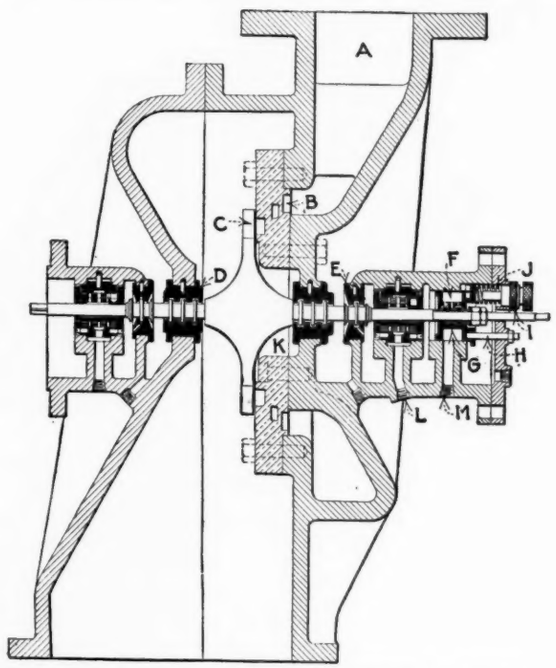


FIG. 1. SECTIONAL VIEW THROUGH TURBINE

of the rotors, and the centrifugal forces and the resulting stresses were carefully calculated, as the speeds that were contemplated were far beyond any that had previously been considered posssible.

As an example of the enormous forces resulting at these high speeds, it may be of interest to note that the pull on one of the blades of the blower rotor, which were only about $\frac{1}{16}$ in. thick by an average of $\frac{11}{16}$ in. wide and 2 in. long, amounted to a little over a ton, though the actual weight of one blade is about $^1/_{40}$ lb.

An examination of the turbine blades (Fig. 1), shows that they are not a good section so far as turbine economy is concerned. This was not serious, as this turbine was not intended to be very economical. At such high blade speeds compared to the steam speed the section of the blades is not of such importance, since then the relative

velocities are low and the losses other than those in the blades and nozzles are small compared to the output, thus permitting a fair economy to be obtained in spite of rather large blade losses.

The reason for the poor blade shape is that as only one of these turbines was built and it was necessary to form the blades integral with the turbine wheel, it would have been expensive to have a profiling machine to cut out the desired blade sections.

To obviate this difficulty, a simple way of forming the blades was devised. This consisted in drilling small radial holes in the rim of the turbine rotor with a round-nosed drill, the number of holes corresponding to the number of blades on the circumference, and the depth was made equal to the height of the blades. After these holes had been drilled, they were reamed out with tapered reamers, thus making the space between them less at the circumference than at the bottom of the holes and giving a decreasing section from base to tip as desired in the finished blades.

The rotor was then put in a milling machine and a narrow slot cut into each hole from both sides of the wheel, the slots being cut in at the desired blade angles and tangent to the inside surface of the holes. A second milling cut was then taken at a smaller angle so as to form the back of the blades and sharpen the edges exposed to the incoming steam. These operations did not leave exactly the desired section on the back of the blades, but this was easily remedied by doubling some coarse emery cloth and pulling it over the backs of the blades until the desired section was obtained.

As even scratches are to be avoided on disks running at such high speeds, it was not permissible to drill holes

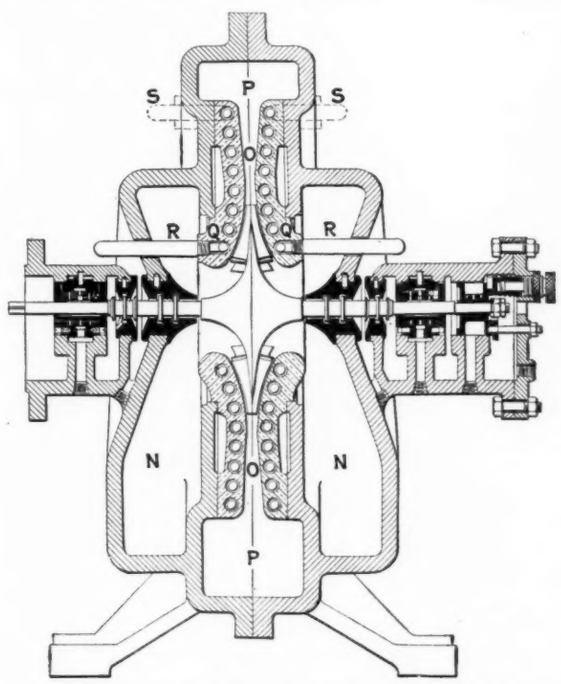


FIG. 2. CROSS-SECTION THROUGH BLOWER

for balancing. A balance was obtained by polishing the backs of the blades on the heavy side with emery cloth, being careful to distribute the polishing so as not to take too much stock from any one blade. The blower rotor was balanced in the same way, except that a little stock was also removed from the central disk between the blades, but this was done very carefully so as to distribute any thinning that might occur and not cause any sudden changes in the stresses in the disk. It may be remarked that the stresses were calculated not to exceed

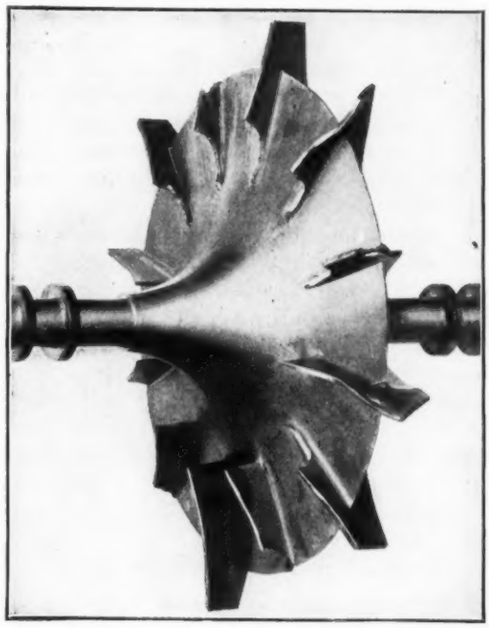


FIG. 3. ROTOR OF BLOWER

40,000 to 45,000 lb. per sq.in. at the highest speed, thus allowing a factor of safety of over two on the elastic limit at the maximum speed.

Longitudinal cross-sections of the assembled turbine and blower are shown in Figs. 1 and 2. The tip diameter of the blower rotor is 8 in. and the tip diameter of the turbine rotor is 8¼ in. The bearings of both the turbine and blower are ½ in. diameter by 2 in. long and are of the sleeve type in which the shaft revolves in an inner tube that is carried in a number of other tubes, each of which is a couple of thousandths larger than the tube within it. The space within the tubes is filled with oil, which acts as a cushion to deaden any vibration and permits the shaft to revolve about its center of mass instead of its geometrical center. This avoids excessive pressures on the bearings, since at high speeds a body revolves about its center of mass and not about its geometrical center, and if the two do not coincide, very heavy loads may be put on the bearings, causing them to be overheated and burnt out.

The effectiveness of the "sleeve" bearings was well shown when, owing to an accident, nearly half of the blades were lost off the blower rotor, the accident not being disclosed by any extra vibration or noise, but simply by the drop in efficiency of the blower and a tendency of the blower bearings to run hot.

Referring to the drawing of the turbine (Fig. 1), the steam enters through the 4-in. inlet *A* and passes to the nozzles *B* where it is expanded and is discharged against the blades *C* of the turbine rotor, after which it passes into the 18-in. exhaust.

The place where the shaft passes through the casing is provided with sealing glands *D* of the simple labyrinth type, because at such high speeds rubbing glands of any form are not suitable and just for experimental

purposes it was not considered necessary to obtain absolute air-tightness. Moreover, the diameter of the shaft at the glands is only 5/8 in., and with the small axial clearances allowed, a labyrinth packing with six throttlings will be practically air-tight. At any rate the small leakage was not serious, and no difficulty was experienced in maintaining 28½ in. of vacuum, which was all that was desired.

Where the shaft enters the bearing housing, oil guards are provided, and oil slingers are fitted on the shaft to prevent the escape of oil along the shaft and permit oil and vapor to be drawn into the turbine glands and find its way to the condenser.

Details of the main bearings can be seen in Fig. 1. To take any end thrust that the turbine might have, a small two-collar thrust bearing was put on the outboard side of the main bearings. It is made in halves, *F* and *G*, the upper half taking the thrust to the right and the lower taking the thrust to the left. In order that there would be no danger of binding by tightening up the separate pieces too much, and still have the effect of no clearance so as to prevent end play, the lower half is adjustable by means of the screw *H* and the upper half is held against the collars by the spring *J* and the spring-adjusting nut *I*.

While it is said that an impulse wheel has no end thrust, this is true under certain conditions, but not in all cases, the thrust being in one direction under some conditions and in the opposite direction under others.

In the turbine under discussion, at very light loads the thrust was not serious and was toward the thrust bearing, and the thrust in this direction increased as the load increased. However, it was found that the thrust became too great as the load was increased, causing the spring *J* to be compressed and letting the rotor move axially, resulting in a rub at the glands.

As the end thrust was obviously caused by the steam issuing from the nozzles, causing an injector action where it entered the blades and thus forming a higher vacuum in the space *K* than existed in the exhaust, a 1¼-in. pipe connection was made from the space *K* to the exhaust pipe. The turbine was tried again, and in order to observe whether there was still an end thrust, the adjusting screw *I* was backed off until only a slight pressure was exerted on the upper half of the thrust bearing. It was then found that as the load was increased the rotor was still forced to the right, but when the screw was tightened the rotor no longer exerted sufficient thrust to compress the spring. Thus it was evident that while the 1¼-in. pipe to the exhaust was sufficient to decrease the difference of pressure on the wheel so that the thrust was no longer serious, still the injector action of the nozzles was sufficient to maintain considerable difference in pressure even with a free flow through a 1¼-in. pipe. This difference in pressure became greater as the speed of the turbine was increased to a high rate.

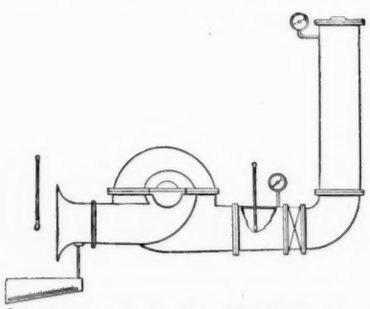


FIG. 4. TEST ARRANGEMENT

Unfortunately, the trouble with end thrust was not all cured, as was found later with the results shown in the accompanying picture of the blower rotor (Fig. 3), which will be referred to later.

After having removed the thrust to the right and having been assured that at least up to 20,000 r.p.m. no serious thrust was developed, it was thought that all the thrust trouble had been eliminated. This was not the case, for as was afterward learned, at about 25,000 r.p.m., when the pressure drop through the turbine nozzles exceeded that through which they could completely expand the steam, the direction of the thrust suddenly changed from right to left and then increased very rapidly with the increase in load and the corresponding increase in steam pressure required.

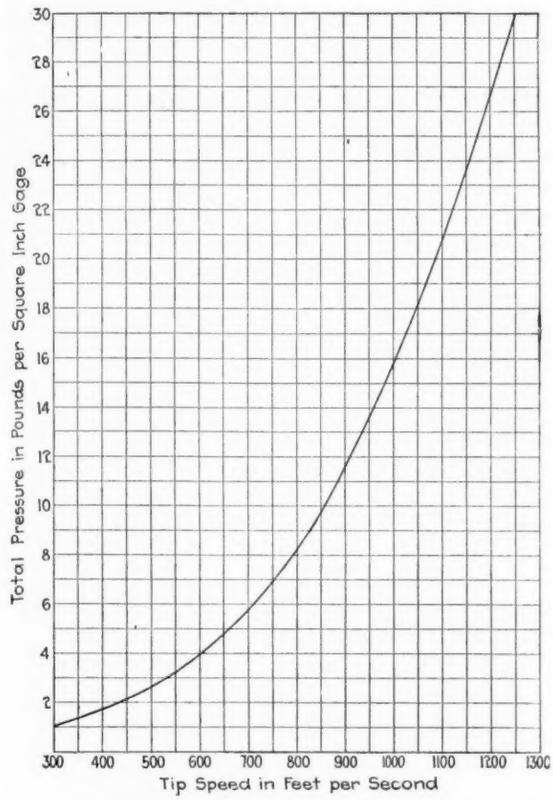


FIG. 5. APPROXIMATE PRESSURES AND TIP SPEEDS OF HIGH-SPEED BLOWER

It should be mentioned here that it was impossible to obtain sufficient area at the outlet of the nozzles, though they occupied the entire circumference, since the pitch diameter of 7 in. with a nozzle width of 1 in. gives only about 21 sq.in. of projected outlet area, which is not sufficient for completely expanding the steam required to develop 350 to 400 hp.

The oil for all the bearings was supplied under pressure from an overhead tank located about ten feet above the bearings, and the oil return was led to a small pump which returned the oil to the tank.

The oil which was fed to the bearings through the openings *L* and *M* in the lower half of the bearing housings was led to the top of the bearings and entered at the point of minimum pressure, there being no holes in the bottom of the bearings; and no grooves were cut in them, as these would only permit the escape of the oil and cause the destruction of the bearings. Separate

inlets were provided for the thrust bearings to insure an ample supply of oil.

As the turbine was made only for experimental purposes, no governor was provided. Since the load on a blower increases as the cube of the revolutions per minute, the speed is easily controlled by a hand throttle, the only danger in this being the breaking of the shaft. However, as the stresses in the shaft did not exceed 20,000 lb. per sq.in., the danger from this source was remote; besides, in experimental work there is always a man at the throttle.

Referring to the blower (Fig. 2), the air enters through the inlets *N*, which are made of the "snail" form with a whirl chamber so as to direct the incoming air in the direction of rotation. The proportions are such that the air has the same velocity as the inside edges of the blades, thus permitting it to enter the blades without shock, and tangentially instead of at an obtuse angle, as it would were the inlet not so formed.

Path of the Air

From the inlets the air enters the blades of the rotor and is there partly compressed and is finally discharged into the whirl chamber *O* where the velocity is gradually reduced to less than half that with which it leaves the tips of the blades. The loss of kinetic energy reappears in the increase in pressure that occurs in the whirl chamber. Over half of the total increase in pressure occurs in the whirl chamber, the efficiency of which, at the designed capacity, reaches over 90 per cent. of the theoretical.

After leaving the whirl chamber, the air is discharged into the collecting passage *P* which is of the "snail" form having a gradually increasing area, the latter increasing directly as the volume of air discharged into it, thus keeping the velocity constant.

The whirl chamber has no guide vanes or reversed nozzles, the velocity conversion being accomplished by a free vortex, the efficiency of which exceeds that obtainable by the most perfect guide vanes. Moreover, this has the advantage of a high efficiency at all discharge rates, whereas the diffusion tubes or guide vanes have a good efficiency only at their designed capacity, for at all other capacities the blade angles are incorrect as well as the areas. Furthermore, guide vanes are noisy and, at the speeds at which this blower was operated, would have been prohibitive.

The side plates *Q* were of brass with copper coils cast in them through which water was to be circulated, entering through the pipes *R* and leaving through *S*, thus having the coldest water exposed to the coldest air.

At first glance the cooling area exposed to the air does not appear large, but it must be remembered that with air velocities of 1,500 to 2,000 ft. per sec. on the outside and a water velocity of 30 to 50 ft. per sec. through the tubes, an extremely high rate of heat transfer per square foot of air surface per degree per hour can be obtained, so that quite effective cooling was to be expected. At least it would have accomplished its real object, which was to prevent too great a rise of temperature when the discharge is entirely closed, and the further object of increasing the pressure, which can be maintained when the discharge is totally closed or open only a small amount, thus increasing the slope of the pressure characteristics.

Owing to the castings for the side rings being defective, the water cooling was not used, and no data on the rate of heat transfer were obtained, the tests being run with the defective castings, as it was intended to run them without cooling first and then repeat them with cooling as soon as perfect castings were obtained.

One of the most serious problems in the design of this blower set was that of getting a suitable coupling for transmitting 400 hp. at 60,000 r.p.m. As the surface speed of the ½ in. diameter bearings is 100 ft. per sec. at 60,000 r.p.m., no form of coupling that would require an increase in the diameter of the shaft could be used, as the sleeve bearings employed have to be slipped on to the shaft. Any form of attached coupling seemed undesirable, as the attachment generally weakened the shaft end too much. For these reasons the old square sleeve-type coupling was employed, the squares being made ⅜ in. with 6-in. space between them.

The long space between the squares made the coupling comparatively flexible, though the fit on the squares was kept down to less than $^1/_{1000}$ in. It was made of tool steel oil-tempered.

This coupling was entirely satisfactory, though it did not permit free end motion under load, as was hoped but not expected, since the pressure on the edges of the

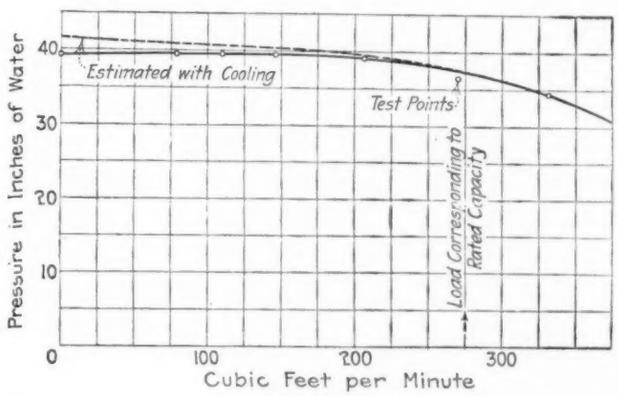


FIG. 6. PRESSURE CURVE AT CONSTANT SPEED OF 8,000 R.P.M.

squares amounted to several thousand pounds and gripped almost like a solid piece of shafting when under load. It was the failure of the coupling to slip which caused the destruction of the blower rotor, for when a heavy end thrust toward the blower was developed in the turbine and the turbine thrust bearing burned out, the turbine rotor simply pushed the blower rotor over and the spring holding the upper half of the blower thrust bearing was compressed, thus permitting the blower rotor to come into contact with the side plate, with the result shown in Fig. 3.

In connection with the damaging of the blower rotor it milled out $^1/_{32}$ to $^1/_{16}$ in. from the side plate, and the end pressure on it was such that the burr turned up on the edges of the remaining blades was on the forward side as well as on the back.

An interesting point about this failure is that none of the men on test noticed anything wrong with the blower and the only evidence that anything had happened was a little smoke coming from the turbine thrust bearing. The machine was shut down and examined, the thrust bearing removed, scraped and put back, after which the

machine was run for three days without anyone suspecting that anything had happened to the blower.

It was only because of the drop in efficiency that it was decided that something must be wrong with the blower, and it was opened up.

The turbine rotor was not injured in the accident, and the only damage done was, the glands and oil guards of both the turbine and blower were worn away, increasing the axial clearances, and the collars on the shaft were "blued" by the heat developed by the rubbing. Aside from an increase in the leakage of the glands, which would not have been serious, all the parts except the blower rotor and the damaged side plate could be used again.

In ordering the new parts for the blower, new thrust bearings were designed of the Kingsbury type, which would have had ample area to take care of any thrust that might be developed, thus eliminating the only trouble that was found. Unfortunately, owing to the death of Mr. Westinghouse, all experimental orders were closed, and this prevented the completion of the experiments, though the new blower rotor and other parts were almost finished.

Arrangements for Testing

The arrangements for testing this blower unit are shown in Fig. 4. A rounded inlet cone with a throat accurately finished and polished to 6 in. diameter was fitted to the inlet, and a differential draft gage was connected to a pressure chamber around the throat, four small holes drilled at right angles to the axis of the inlet communicating with the pressure chamber and the throat of the nozzle. A thermometer was suspended in front of the inlet to obtain the temperature of the entering air. A second thermometer was placed in the discharge of the blower, and at the same point as indicated in the diagram the pressure was observed by means of a mercury column for the lower pressures and a calibrated test gage for the higher pressures.

Just beyond the thermometer and gage connections at the outlet, a gate valve was placed to throttle the discharge as desired. An elbow was located just beyond the gate valve, and a piece of pipe was attached to carry the discharge well above the heads of the testers. On the end of the pipe a second nozzle was fitted, well rounded and polished to a 2½-in. diameter throat.

A gage connection was made about 6 in. below the nozzle for obtaining the pressure, this second nozzle being used as a check on the inlet nozzle, and it may be mentioned that the volume calculated from the two nozzles agreed within less than 2 per cent., a nozzle coefficient of 99 being used for the inlet nozzle and a coefficient of 97.5 for the discharge nozzle.

The table shows a few readings taken before the rotor was damaged, the efficiencies being those calculated from the increase in temperature of the air in passing through the blower. The thermometer in the discharge, it may be noted, was inserted directly in the air instead of by a thermometer well as is usual, since readings taken with the thermometer inserted in a well are always too low in the case of air because of the radiation from the pipe and the comparatively small heat capacity of air.

The approximate pressure that can be created by any blower of similar design to that here referred to can be obtained from the curve shown in Fig. 5, provided that the atmospheric pressure is approximately 29 in. of mercury and the temperature of the air at the intake is not very different from that assumed in calculating the curve; namely, 70 deg. F.

If the atmospheric pressure is higher than 29 in., the tip speed required to give a stated pressure will be lower, and if the atmospheric pressure is lower, the tip speed for a given pressure must be higher. Likewise, if the temperature of the entering air is higher than 70 deg. F., the required tip speed is higher, and if the temperature is less, the tip speed required to maintain a given pressure will be less. This curve can be checked by the blower tests given, and it will be found that with the slight corrections for barometer and temperature the test results agree with the curve.

The speeds up to 10,000 r.p.m. were taken by a tachometer and carefully checked by means of an ordinary revolution counter, and between 10,000 and 20,000 r.p.m. the speed was taken by a tachometer belted to the extension of the blower shaft, the belted tachometer being calibrated up to 10,000 r.p.m. of the turbine shaft by taking the speed of the latter with a revolution counter and the calibrated direct-reading tachometer. Beyond 20,000 r.p.m. the speed was calculated from the pressure created by the blower, and the writer believes that, barring an accident to the rotor, as in the present machine, for these very high speeds the calculated speed is probably at least as accurate as the observed speed, when the correct formula is used. The speeds in the table are therefore calculated for everything over 20,000 r.p.m.

RESULTS SHOWN BY THE TESTS

Barometer	28.88	....	....	....	....	....
Steam-chest pressure	....	10	20	30	88	
Air-discharge pressure	4.5*	9.1*	14.25*	18.5*	24 lb.	
Temperature of discharged air, deg. F.	94	122	153	178	348	
Revolutions per minute	12,600	16,800	21,000	23,000	32,000	
Vacuum	....	26 in.	26	26.5	26	
Vacuum at blower nozzle throat, in. water	0.66	1.22	1.78	2.09	3.00	
Adiabatic efficiency, per cent.	64	68	67.5	66	66.8	
Cubic feet of free air per minute discharged	633	860	1,040	1,130	1,360	
Temperature of air at inlet nozzle, deg. F.	59	59	58	56	78	

*These pressures are in inches of mercury.

It was just after increasing the speed following the run at 24 lb. per sq.in. that the turbine thrust bearing was burned out and the machine had to be shut down. After the turbine had been reassembled, the highest pressure reached before the thrust was again burned out was 23.5 lb. per sq.in., and while this corresponded to a higher steam inlet pressure, it was evident that the thrust was too great for the bearings. The highest efficiency obtained after the accident was about 56 or 57 per cent.

The characteristic curve of this blower is shown in Fig. 6, in which it will be seen that for a large variation of the capacity the pressure remains practically constant and then falls off with a further increase in the delivery. There is a slight increase in pressure from no load for a small range of capacity, as was expected without the water cooling, because the sides of the whirl chamber were given an outward taper to increase the area through it, which has the effect of making a slightly increasing pressure characteristic, which can, however, be overcome by the use of water jackets around the rotor and whirl chamber. Water cooling the outside casing would not have this effect.

The most remarkable feature about the performance of this blower was its action with the discharge entirely shut off and with the discharge open only a small amount. At no discharge there was upsetting as was to be expected, as this is of course unavoidable in any blower, but the surprising thing was the slight pressure variation that occurred and the further fact that opening the discharge ever so little caused it to decrease to such an extent as to be hardly noticeable. At 2 per cent. of the rating of the blower all traces of upsetting disappeared, and with the water cooling all signs of upsetting would doubtless have ceased at less than 1 per cent. of the rating. This is one result that could never have been obtained in a blower fitted with guide vanes.

In looking over the test results, it should be borne in mind that this blower was designed to have a capacity of only 1,500 cu.ft. per min. against a pressure of 50 lb. per sq.in. in the discharge, but in spite of that fact gave an efficiency of 67 or 68 per cent. without water cooling, which is as high as has been obtained on many multiple-stage water-jacketed blowers with coolers between the stages and of 25,000 to 55,000 cu.ft. per min. capacity. This is certainly a remarkable justification of the single-stage blower for high pressures.

From the test data presented, it will be seen that the designed pressure of 50 lb. per sq.in. at 43,500 r.p.m. and 1,500 cu.ft. per min. capacity would have easily been attained had the thrust bearing not burned out and caused the destruction of the blower rotor.

Water-Pump Packing Worn

By E. C. Parham

If a motor-driven reciprocating water pump be started with the discharge valve closed and the piston and gland packings happen to be in first-class condition, the pump cylinder is liable to be cracked as a result of the abnormal pressures so suddenly imposed. Water practically is incompressible, and any force that is exerted to compress it is at once transmitted to the container; and in the case of the motor-driven compressor, destructive strains may result before a circuit-breaker or a fuse in the motor circuit can respond to the overload or, should the pump be belt-driven, before the slipping of the belt can relieve the situation. Under the special condition of the piston needing repacking very badly, however, nothing serious or even annoying may occur, because the water is then forced through the clearance between the piston and the cylinder walls. That this clearance may be sufficient to enable the motor to operate the compressor with the discharge valve closed and without harmful results is shown by the following:

The amount of water delivered by a motor-driven compressor to the tank of a sprinkler system and house supply had gradually been decreasing for some time. As the motor had been rewound recently, it was thought to be responsible for a part of the falling off in delivery, although worn packing was suspected as the major cause.

During a test made to ascertain exactly what the motor was doing, the suspicion of leaky piston packing was confirmed in a very unexpected manner. The measuring of the water delivered to a barrel during an interval of two minutes had just been completed when it was noticed that the ammeter deflection increased about 30 per cent. and at the same time the motor belt was heard to squeak. On looking around it was observed that the valve to the measuring hose had been closed without opening the valve to the tank, so that the compressor was working without an outlet. If there had been any doubt as to whether the piston needed repacking, this removed it.

Rotor-Bar Insulation

The question of insulating the rotor bars of a squirrel-cage induction motor is one that has been given considerable discussion, especially since several of the manufacturers are building motors of this type without any insulation on the rotor conductors. The method of construction is to make the bar and the slot about the same size, which means that the bar must be forced into the slot under pressure. Considerable argument has been given against this practice.

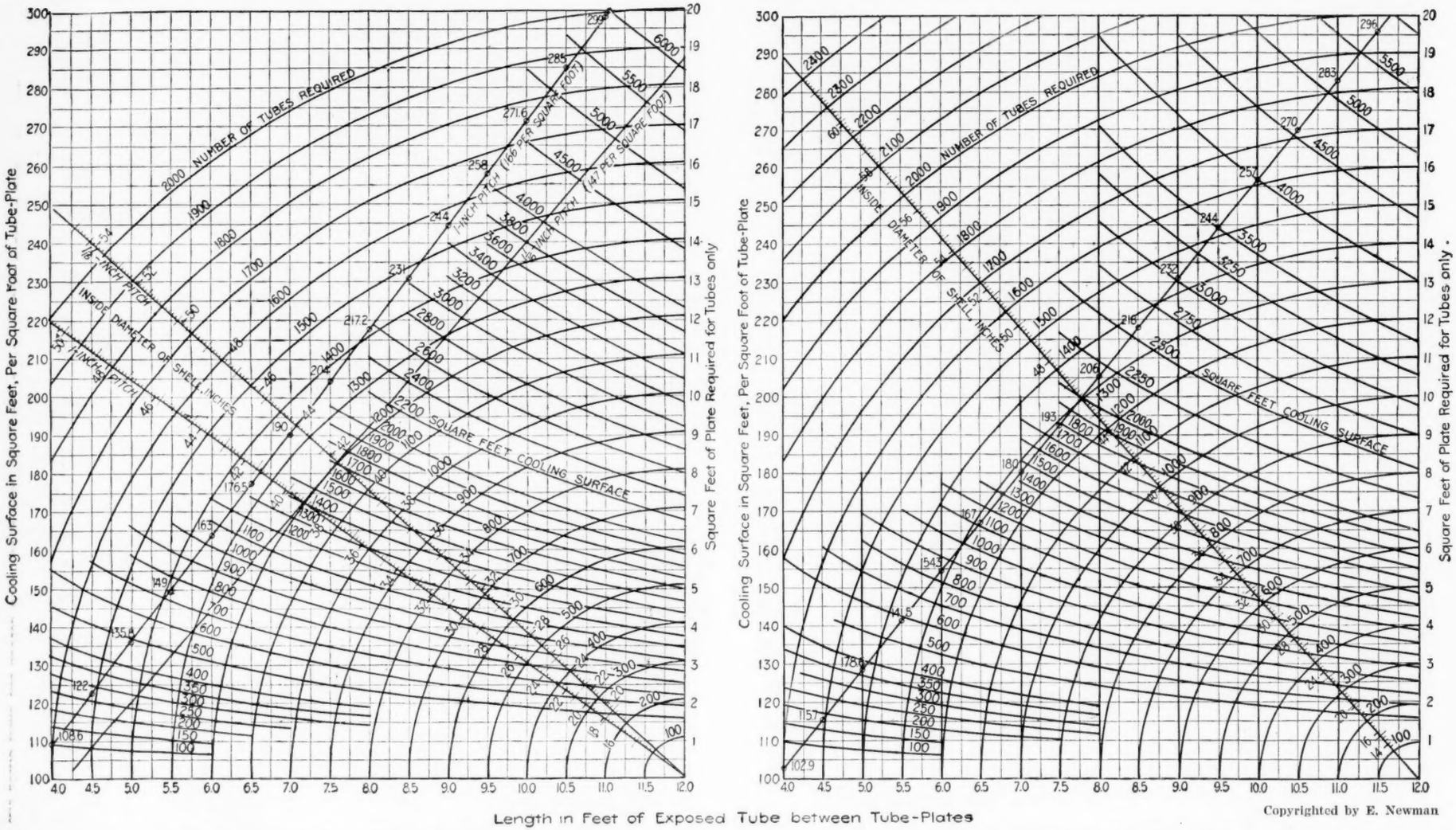
Not infrequently is it claimed that on rotors with insulated bars slow speed has been experienced when the conductors became ground to the core, and that this trouble was remedied by re-insulating the rotor winding.

Careful tests have been run on induction motors, both with insulated and uninsulated rotor conductors, and in comparing these tests it was impossible to identify the rotors by the test results. Therefore it would seem that there is nothing gained by insulating the rotor bars. On the other hand, if there was a slight difference in favor of the machine with the insulated bars, this would be offset by the greater mechanical stability of the uninsulated construction.

The insulation on the bars in many cases becomes burnt, allowing them to work loose and vibrate, causing noisy operation of the machine. This vibration eventually causes loose joints between the bars and end rings, and loose joints mean high resistance in the rotor circuit. Here is the reason why the rotor speed was corrected by what appeared to be the re-insulating of the bars. The higher the rotor resistance the greater is the decrease in speed from no load to full load. If the joints between the rotor bars and end rings work loose, the resistance of the joints increases. This causes a greater increase in the rotor temperature, which further increases the resistance of the conductors, which results in a reduction in speed. When the rotor is re-insulated it is not the insulation on the bars that remedies the trouble, but restoring the joints between the end rings and bars to normal condition. In reassembling the rotor one of the most likely things for a good workman to do would be to carefully clean and tighten the joints in the rotor copper structure and thus remedy the cause of the trouble.

Many of the modern induction motors are constructed with end rings welded to the bars, or cast on, as the case may be. Such construction does not lend itself to insulating the bars, both on account of the high temperature used to put the end rings on and also the difficulty that would be experienced should it become necessary to re-insulate the rotor. Machines with welded or cast-on end rings and no rotor insulations are immune from all troubles due to loose bars and poor contact between the bars and the end rings.

An Automatic Stop Valve is just as much a necessary safety device for a boiler as a safety valve. And an automatic valve doesn't cost over 5 per cent. more than an ordinary stop valve of like size. Then considered as safety insurance, the investment in a good automatic valve for each boiler is about as much for the money as could be had in most any other way.


Cooling Surface in Square Feet, Per Square Foot of Tube-Plate
Square Feet of Plate Required for Tubes only
Length in Feet of Exposed Tube between Tube-Plates
NUMBER OF TUBES REQUIRED
SQUARE FEET COOLING SURFACE
INSIDE DIAMETER OF SHELL, INCHES
1⅛-INCH PITCH
1¼-INCH PITCH
1⅜-INCH PITCH
1½-INCH PITCH
1 INCH PITCH (166 PER SQUARE FOOT)
¾ INCH PITCH (147 PER SQUARE FOOT)

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SURFACE CONDENSER CHARTS, GIVING INSIDE DIAMETER OF SHELL AND NUMBER OF TUBES FOR VARIOUS AMOUNTS OF COOLING SURFACE—LEFT-HAND CHART ⅝-IN. OUTSIDE DIAMETER TUBES, 1-IN. PITCH; RIGHT-HAND CHART ¾-IN. TUBES, 1⅛-IN. PITCH

Example—Required the number of ¾-in. tubes and inside diameter of condenser having 1,000 sq.ft. of cooling surface. Assume the tubes to be 8 ft. long. Enter the curve marked 8 ft. (right-hand chart) and follow vertically to curve of 1,000 sq.ft. of cooling surface; then proceed horizontally to the diagonal, showing the number of tubes to be 637 and the shell 32 in. inside diameter. Caution—When using the 1 1/16-in. pitch line (left-hand chart) do not take the cooling-surface curves as plotted, but take the nearest curve as found by 1.13 × cooling surface. Thus, if 1,500 sq.ft. of cooling surface is required with the tubes pitched 1 1/16 in., use 1,500 × 1.13 = 1,700 curve.

The Induction Generator

By H. M. Phillips

SYNOPSIS—A discussion of the fundamental principles of the induction generator, its applications and limitations. The author points out that although this machine is very rugged in its construction it has never been used to any great extent because it must always operate in parallel with a synchronous alternator.

The ordinary squirrel-cage induction motor is so seldom used as a generator that many engineers fail to realize that there are some cases where it can be so used to decided advantage.

The facts that a generator of this type cannot be made self-exciting and that an alternator (which must have a direct-current exciter) is necessary to furnish the exciting current are enough to prohibit its use in the great majority of cases. Furthermore, it is likely to be slightly less efficient than an ordinary alternating-current generator and supplies current at somewhat less than unity power factor; in most cases neither of these deficiencies is of serious consequence. On the other hand, we have the characteristics of a squirrel-cage motor—namely, simplicity and a gratifying ability to take care of itself.

Characteristics of an Induction Motor

If the rotor of an induction motor is prevented from turning and the stator is connected to a source of alternating current, there will be induced in the rotor conductors a current of the same frequency and voltage as that in the stator winding, but opposite in direction to that in the stator. In other words, the condition is that of a transformer, the stator winding corresponding to the primary and the rotor to the secondary winding. The current in the secondary being opposite to that in the primary, will have a tendency to decrease the magnetic flux. If the rotor is allowed to revolve, it will run up to almost synchronous speed; and the frequency and voltage in the rotor will have decreased to very nearly zero, becoming zero at synchronous speed. If power is applied to the rotor and it is driven above synchronous speed, the rotor conductors will then be cutting the lines of force in an opposite direction; consequently, the rotor current will reverse and instead of being in a direction to oppose the magnetism set up by the stator current it will be assisting and cause an increase in the flux density. Under normal conditions the counter electromotive force in the stator winding is almost equal to the applied voltage. Therefore, if the rotor current is reversed and the flux increased, the counter electromotive force will become greater than the applied electromotive force, causing the machine to become a generator and supply current to the line. When operated as such, it is called an induction generator.

A notable induction-generator installation is that of a large central station where the main generators are driven by reciprocating engines. To increase the capacity and at the same time increase the efficiency of the plant, induction generators of the same capacity as the main generators were installed and driven by low-pressure turbines, taking the exhaust steam from the reciprocating engine. This made it possible to double the capacity of the plant.

The load carried by an induction generator will be in proportion to the amount that its speed exceeds synchronism. On an average it may be assumed that full load will be carried at 3 per cent. above synchronous speed, in which case a 50 per cent. overload would be carried at 4.5 per cent. above synchronous speed. Other applications of the induction generator are given in the following:

A small water power is available that has not capacity enough to supply the entire demand of the system. Install an induction generator capable of carrying all the load that can be developed by the waterwheel and connect the machine in on the system with the waterwheel governor set at about 5 per cent. above the synchronous speed of the generator. All the power that the wheel can furnish will then be utilized, and the installations will require practically no attention. When power is cut off at the main plant, the machine ceases to act as a generator and drops its load, to pick it up again as soon as the line is excited from the main plant. The line from the water power need not be carried back to the main power house; it can be connected in at any point on the system.

The electrical part of the system should require inspection not more than once a week, going entirely unattended for the remainder of the time. Whether or not the water power would require more frequent visits would depend upon the apparatus used and upon local conditions. It might even be possible to operate the waterwheel without a governor, if a safe speed is not exceeded when power is thrown off the line. Machines of this type are generally capable of standing a material increase in speed, and the rotor may be designed to meet such an emergency if necessary. In this instance it would probably be advisable to bring the waterwheel back to normal speed before throwing current on the system.

Load on Exhaust-Steam Turbines

A somewhat similar case occurs when it is desired to utilize low-pressure steam for heating purposes. A steam turbine capable of furnishing exhaust steam at the required pressure and in sufficient quantity may be connected to an induction generator that can carry the maximum output of the turbine. In place of the ordinary turbine governor, install a reducing valve, with the pressure connection to its regulating mechanism taken from the turbine exhaust. This system is especially desirable when, on account of distance or any other reason, it is not feasible to obtain the required steam from the main power plant. The emergency governor on the turbine should remain in service; and the regular governor set at 5 per cent. above synchronous speed may be retained to advantage, as it will enable current to be thrown on without any adjustments after a temporary failure of power from the main plant. It may be mentioned that if steam is entirely cut off from the turbine through failure to utilize the exhaust or any other cause, the generator will continue to drive it at practically full speed, which may be bad for the turbine and should be guarded against if necessary.

The same system offers excellent opportunities for the use of exhaust-steam turbines in various parts of a plant from which it is impractical to return the exhaust to the main power plant.

A reciprocating engine driving a lineshaft or other apparatus is of course very inefficient on light loads. Perhaps it is compelled to run on light loads a large percentage of the time and is subject to occasional overloads that it is unable to carry. There is little doubt that such cases require a radical change in the power system; but if alternating current is available from another source, the induction motor may be a quick means of obtaining temporary relief on the overloads and an improvement in efficiency. The induction motor may be belted to the lineshaft or connected in the most convenient manner. If the engine governor is adjusted to drive the motor at synchronous speed while operating at its usual load, the motor will be practically inactive until the overload comes; then a slight slackening of the engine speed will cause the motor to help out in the time of need. Increase the speed of the engine slightly and the motor will act as a generator during the periods when the original load is low and be equally efficient as a helper on overloads, with a decided improvement in the efficiency of the entire plant.

If the outside power for the last-mentioned installation were obtained from a power company at meter rates, it might be found that although the power company carried the peak loads it received more power, from the motor acting as generator, than it delivered and was therefore in debt to the isolated plant. It is feared that it would be difficult to find a power company that would pay such indebtedness or agree to furnish power without a substantial cash return.

In using the belted motor as a generator the subject of belt slip is of unusual importance. A belt may have a slip of 4 per cent. without giving any marked evidence of the fact. Suppose such a belt is driving the motor at 2 per cent. above its rated speed, which would cause it to act as a generator delivering about two-thirds of its rated horsepower. By tightening the belt or by the application of dressing, the belt slip may be reduced to 2 per cent. This will bring the motor up to 4 per cent. above rated speed and double its output as a generator, causing it to carry an overload of about one-third its rated capacity.

Although it would be theoretically possible to obtain any of the foregoing results with an induction generator, in many cases the complications in doing so, or the amount of the engineer's time required for the necessary supervision and adjustments, would make the idea impracticable.

Cause of Fuses Blowing

It is not an uncommon idea that the voltage and not the current causes a fuse to blow, that a fuse of larger cross-section is required for a 220-volt circuit than for a 110-volt circuit. The heating of an electric circuit is caused by the current that flows through it and not by the voltage impressed upon it. What causes a fuse to blow is excessive heating produced by a greater current than that which it was intended to carry. The heating in any circuit is proportional to the watts (I^2R) expended in the circuit and varies as the square of the current. That is, if the value of the current flowing in a given circuit is doubled the temperature is not increased in the same ratio, but by the square of 2, or 4 times.

Fuses in most cases are made of an alloy composed of tin, lead and bismuth and are designed so that they will carry a current indefinitely 10 per cent. in excess of that which they are intended for. At a current 25 per cent. greater than their rating, fuses will open the circuit in from 1 to 15 min., depending upon the size of the fuse. Under this condition it would be a case of the fuse reaching a temperature high enough to cause it to melt and fall out of the circuit. On the other hand, when a short-circuit occurs, the fuse is not merely melted, but the temperature becomes so high that the fuse is vaporized.

Assume that the normal current of a 5-amp. fuse causes its temperature to increase 125 deg. F. above the surrounding air and that an overload on the circuit increases the current to five times normal value, or 25 amp. The increase in temperature caused by the current would equal the square of the number of times the normal current has been increased, multiplied by the increase in temperature caused by the normal current, or in this case $5 \times 5 \times 125 = 3{,}125$ deg. F. This value is only theoretical, for long before the fuse has time to reach this temperature it has opened the circuit; but the rapid increase in temperature caused by the increase in the current shows why a short-circuit causes the fuse to become vapor. The foregoing value is very low for a short-circuit current. It is not uncommon for the current in a circuit to increase 20 to 25 times the normal rating of the fuse on a short-circuit before the circuit opens, which is almost instantaneous. The only difference between a 30-amp. fuse for a 110-volt circuit and a 30-amp. fuse for a 600-volt circuit is the length. The former must not be less than 2 in. long; the latter not less than 5 in. The reason for this increased length is on account of the high voltage having a greater tendency to maintain an arc across the fuse terminals.

Data Pertaining to Water

By G. C. Long

The following data on water is information that the engineer frequently needs but seldom has available. While of course not original, I think it will be appreciated by readers who have no library at their command or haven't this information collected in a compact form:

One U. S. gallon has a volume of 231 cu.in. and weighs 8⅓ lb.
One cubic foot of water at 39.1 deg. weighs 62.426 lb.
One second-foot means one cubic foot of water delivered per second.
One second-foot equals 7.48 U. S. gal. per sec.
One second-foot equals 6.23 British gal. per sec.
One second-foot equals one acre-inch per hour approximately.
One acre-foot means one acre covered with water to a depth of one foot.
One acre-foot contains 325,851 gal. of water.
Friction of water in pipes increases as the square of the velocity.
Friction of water in pipes varies inversely as the fifth power of the diameters.
Friction of water in pipes increases directly as the length.
To find the approximate theoretical horsepower required to lift water to a given height, multiply the U. S. gallons by the feet lift and divide by 4,000, making an allowance for losses in the pump.

The equivalent of any number of cubic feet or gallons can be easily determined by the use of the following tabulation:

1 cu.ft.	= 7.48 gal.	1 gal.	= 0.134 cu.ft.
2 cu.ft.	= 14.94 gal.	2 gal.	= 0.267 cu.ft.
3 cu.ft.	= 22.44 gal.	3 gal.	= 0.401 cu.ft.
4 cu.ft.	= 29.92 gal.	4 gal.	= 0.535 cu.ft.
5 cu.ft.	= 37.40 gal.	5 gal.	= 0.668 cu.ft.
6 cu.ft.	= 44.88 gal.	6 gal.	= 0.802 cu.ft.
7 cu.ft.	= 52.36 gal.	7 gal.	= 0.936 cu.ft.
8 cu.ft.	= 59.84 gal.	8 gal.	= 1.069 cu.ft.
9 cu.ft.	= 67.32 gal.	9 gal.	= 1.203 cu.ft.
10 cu.ft.	= 74.80 gal.	10 gal.	= 1.337 cu.ft.

One pound of water pressure per square inch is equal to a column of water 2.3 ft. in height.
One foot of height in a column of water is equal to a pressure of 0.434 per sq.in.

When You See a Useful Fact or Statement, Nail It. Put it where you can find it when wanted, and your reserve fund of knowledge will soon grow tremendously.

INSPECTION CHART

Machine	Location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Work to be Performed
Fire pump	Old power house	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	See instructions No. 1
General service pump	Old power house	0						0						0						0						0						0	See instructions No. 2
Sprinkler risers	Entire plant	S							S							S							S	S					S			See instructions No. 3
Belt-driven elevators	Entire plant		S							S							S							S						S		See instructions No. 4
Electric elevator	Warehouse		E							E														S					E	S		See instructions No. 5
Power motors	Entire plant	E	S						E	S						E	S						E						E			See instructions No. 6
Power motors	Entire plant	E														E																	See instructions No. 7
Steam heating	Entire plant	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	See instructions No. 8
Sprinkler tank	Next to office	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	See instructions No. 9
Air compressor	First floor steel		S				S				S				S				S				S				S			S		See instructions No. 12
Portable electric drills	Entire steel plant	E							E							E							E						E			Oil and repair inspection record is in M. M. office
Alcohol feeder	Second floor steel	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	See instructions No. 14
Main belt of engine	New power house	B		B		B		B		B		B		B		B		B		B		B		B		B		B		B		B	Repair open laps at once
Main belt of generators	New power house	B		B		B		B		B		B		B		B		B		B		B		B		B		B		B			Repair open laps at once
Intake from river	Lumber yard	O						O						O						O						O							General examination
Johnson service pump	Office basement	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	See instructions No. 18
Main belt of engine	Old power house		B				B				B					B			B				B				B				B		Repair open laps at once
Low-pressure steam traps	Entire plant		S							S							S							S						S		See instructions No. 20
High-pressure steam traps	Entire plant		S				S			S				S			S				S			S				S		S		See instructions No. 21
Fire-doors	Entire plant	W							W							W							W						W			See instructions No. 23
Fire pails and hose	Entire plant	W							W					X		W				X			W				X		W			See instructions No. 24
Plant inspection						X								S						S							X					See instructions No. 26
Lumber dry kilns	Entire plant					S								S						S							S					See instructions No. 28
Steel enamel ovens	Third steel					S								S						S							S					See instructions No. 28
Wood enamel ovens	Fourth warehouse					S								S						S							S					See instructions No. 28
Air-brush equipment	Fourth warehouse											S														S							See instructions No. 29
Air-brush equipment	Third steel											S														S							See instructions No. 29
Dictaphones	Main office			M						M								M							M						M		See instructions No. 30
Pencil sharpeners	Main office			M																							†						See instructions No. 30
Roofs and down spouts	Entire plant											†																					See instructions No. 31
Time clocks	Entire plant																*															*	See instructions No. 32
Time clocks	Entire plant			*						*							*							*						*			See instructions No. 33

Symbols

Electrician	E
Steam fitter	S
Millwright	W
Engineer old power house	O
Belt-repairman	B
Assistant master mechanic	X
Engineer new power house	N
Machinist	M
Master mechanic	†
Machine-shop apprentice	*

Note: When inspection discloses apparatus out of order, it must be reported to the mechanical superintendent's office at once and the person making such report can prove himself blameless only by personally witnessing the making out of a shop order for the execution of the work reported. In case the date indicated falls on Sunday or a holiday the work must be performed the day previous. The yellow inspection record must show your signature and the date in order to prove that you or your substitute executed the work as above. Inspection records must be hung in conspicuous locations and kept up to date. Remember that your work is watched by officials at the inspection record.

Instructions

No. 1
Run the pump with discharge open to atmosphere until water is being lifted and passed through the pump. This will keep valves free and in working condition While pump is moving pass cylinder oil through lubricator freely and oil outside parts while in motion.

No. 2
This pump is to receive its regular daily attention, but every week the number of strokes per minute in actual service and number of strokes per minute with water discharge valve closed (steam through the same position) shall be recorded on inspection sheet.

No. 3
The system is to receive the same general attention as at present. On these days special inspection is to be made and gage pressures indicated are to be entered on inspection sheets. All alarms are to be tested and annunciator drops in power houses observed. If any part is not in proper working order report at once to master mechanic's office.

No. 4
Oil all parts and carefully examine lubrication inside worm gear. Inspect all safety appliances, cables, gates and overhead sheaves Inspect all belting driving the machine, and also supporting bolts and nuts, both on the hoisting apparatus and overhead work.

No. 5
Run the elevator and observe the condition of the motor and controller. Make immediate repairs however small. See to lubrication of all bearings and worm gear. Examine all safety appliances and see that all overhead work is safe.

No. 6
Oil bearings, and on d-c. motors see that brushes and commutators are in good order. Examine belts carefully and see that nuts and bolts by which the motors are suspended are tight. Wipe dust off parts.

No. 7
Blow dust from windings and wipe clean. This means that motors and compensators shall be well kept so far as cleanliness in every respect is concerned.

No. 8
Change valves from live steam to exhaust steam 7 a.m. and reverse at 6 p.m., during the heating period of the year, located on second floor steel plant and second floor warehouse, also fourth floor of warehouse in finishing room. Also wind the thermostats twice each day, located—6 in steel plant 2 in warehouse.

No. 9
During the time of year when the outside temperature is 40 deg. F. or less, temperature observations shall be made two times in the forenoon and two times in the afternoon also once at 10 p.m. and at 4 a.m. by the night man. The water shall never be allowed to get colder than 40 deg. Each time steam is put on engineer shall go into tankpit to see if properly operating.

No. 12
Carefully examine all bearings and drive belt. See that the oil in crank case is of proper height. Change oil in crank case every 90 days. When old oil is tapped off, wash out with kerosene before putting in fresh oil. Requires 5 gal. to fill; use auto oil.

No. 14
Put 1 pt. wood alcohol into feeder. 8 a.m. and 3 p.m. each day during cold weather to prevent freezing.

No. 18
Oil, inspect and wipe clean during heating term.

No. 20
Inspect every morning during heating period of year, 2 in old fan house, 1 in old machine shop.

No. 21
Inspect in general and see that traps are in working order. 3 located in fan room, first floor new "B"; new power house basement on headers 1; factory "C" basement on glue heaters 2; steel plant second floor 1; machine shop from enamel kilns 6; warehouse basement 1; on third floor 1. Old power house 2; type shop 2.

No. 23
Examine every fire-door in plant and see that they are in working order and not obstructed.

No. 24
See that all fire pails are in place and filled also that water is not stagnant. Also see that hose is in good working condition.

No. 26
Make complete tour of entire plant and observe general condition of machinery.

No. 28
Inspect all valves, piping, thermostats and controls. Interview man in charge to get complaints and information regarding the behavior of apparatus.

No. 29
Examine general conditions and have repairs needed made at once. These devices must be kept in the best of condition.

No. 30
Oil dictaphones and make such repairs as are required. See that all pencil sharpeners are in working order.

No. 31
Inspect all roofs.

No. 32
Reset time clocks for dates.

No. 33
Wind time clocks and set same.

INSPECTION CHART IN USE AT PLANT OF THE HAMILTON MFG. CO., TWO RIVERS, WIS.

Initial and Operating Costs of Power Plants

By Robert P. Kehoe

The accompanying table is a good basis for determining the most advantageous type of power plant from 100 to 500 hp. As a comparison the figures are fairly accurate, but of course should be modified in every instance to correspond with local conditions. The method shown suggests those items of expense that may be included in the total annual expense for power.

Power plants for general purposes are considered; that is, a main driving equipment consisting of one or more units for operating other equipment by rope, belt or other form of transmission. A lighting plant must be figured differently, since central-station current would not entail any machinery on the premises, while in the other two cases a steam plant or oil engine would have to be furnished in addition to a generator for producing the current. Moreover, the power cost would also have to be calculated in a different manner.

In determining the horsepower of an engine to operate a generator, the loss through transmission and in efficiency of the generator would increase the requirements and 1½ hp. for each kilowatt is therefore used for rough calculation.

TABLE OF INITIAL AND OPERATING COST OF GENERAL POWER PLANTS

(The Costs for Oil-Engine Plants Is Based on the Normal [Peace Time] Cost of Oil)

Rated Horsepower	100 Hp.			300 Hp.			500 Hp.		
Type of motive power	Steam (Simple)	Electric Motor	Oil Engine	Steam (Compound)	Electric Motor	Oil Engine	Steam (Compound)	Electric Motor	Oil Engine
Investment, based on average conditions, including power plant complete, installed	$5,900	$3,800	$7,000	$16,000	$10,300	$21,000	$23,000	$15,000	$30,000
Daily Operating Expense									
Full load 24 hr	.....	2c. rate 1c. rate	.....	.....	2c. rate 1c. rate	.....	.....	2c. rate 1c. rate	.....
Chief engineer	$4.00	$4.00 $4.00	$5.00	$5.00	$5.00 $5.00	$6.00	$6.00	$6.00 $6.00	$7.00
Night engineer, if any	3.00	3.00 3.00	4.00	4.00	4.00 4.00	5.00	4.50	4.50 4.50	5.50
Oilers or assistants	.....	....	.....	4.00	4.00 4.00	4.00	4.00	4.00 4.00	4.00
Firemen	4.00	....	.....	4.00	....	.....	4.00	....	.....
Lubricating oil, waste, supplies and incidentals	2.00	1.00 1.00	2.00	4.00	2.00 2.00	4.00	6.00	3.00 3.00	6.00
Fuel (or Power)									
Coal at $3.50 per ton	16.00	.....	.....	32.00	.....	.....	48.00	.....	.....
Current	.....	40.80 20.40	.....	.....	122.40 61.20	.....	.....	204.00 102.00	.....
Crude or fuel oil at 3¼c. per gal	.....	....	6.00	.....	....	17.00	.....	....	28.00
Net operating expense per 24 hr	$29.00	$18.80 $28.40	$17.00	$53.00	$137.40 $76.20	$36.00	$72.50	$221.50 $119.50	$50.50
Yearly summary—average 8 hr. Daily Operation with 50 Per Cent. Load Factor									
Labor, oil, waste, etc	$2,520	$1,620 $1,620	$2,160	$3,960	$2,880 $2,880	$3,600	$4,680	$3,420 $3,420	$4,320
Fuel or power	1,056	2,448 1,224	360	2,112	7,344 3,672	1,020	3,168	12,240 6,120	1,680
Depreciation, 5 per cent	295	190 190	350	800	515 515	1,050	1,150	750 750	1,500
Repairs 5 per cent. annually on oil engine and steam plants, 2 per cent. on motor	295	76 76	350	800	206 206	1,050	1,150	300 300	1,500
Total Annual Expense (exclusive of interest)	$4,166	$4,334 $3,110	$3,220	$7,672	$10,945 $7,273	$6,720	$10,148	$16,710 $10,590	$9,000
Yearly Summary—Average 10-Hr. Daily Operation with 80 Per Cent. Load Factor									
Labor, oil, waste, etc	$2,520	$1,620 $1,620	$2,160	$3,960	$2,880 $2,880	$3,600	$4,680	$3,420 $3,420	$4,320
Fuel or power	2,112	4,896 2,448	720	4,224	14,688 7,344	2,040	6,336	24,480 12,240	3,360
Depreciation 5 per cent	295	190 190	350	800	515 515	1,050	1,150	750 750	1,500
Repairs 5 per cent. annually on oil engines and steam plants, 2 per cent. on motor	295	76 76	350	800	206 206	1,050	1,150	300 300	1,500
Total Annual Expense (exclusive of interest)	$5,222	$6,782 $4,334	$3,580	$9,784	$18,289 $10,945	$7,740	$13,316	$28,950 $16,710	$10,680
Yearly Summary—Average 50 Per Cent. Load Factor and 24-Hr. Operation									
Labor, oil, waste, etc	$4,680	$2,880 $2,880	$3,960	$7,560	$5,400 $5,400	$6,840	$8,790	$6,300 $6,300	$8,100
Fuel or power	2,880	7,344 3,672	1,080	5,760	22,032 11,016	3,060	8,640	36,720 18,360	5,040
Depreciation 5 per cent	295	190 190	350	800	515 515	1,050	1,150	750 750	1,500
Repairs 7 per cent. annually on oil engines and steam plants, 3 per cent. on motors	413	114 114	490	1,120	309 309	1,470	1,610	450 450	2,100
Total Annual Expense (exclusive of interest)	$8,268	$10,528 $6,856	$5,880	$15,240	$28,256 $17,240	$12,420	$20,190	$44,220 $25,860	$16,740
Yearly Summary—Average 75 Per Cent. Load Factor and 24-Hr. Operation									
Labor, oil, waste, etc	$4,680	$2,880 $2,880	$3,960	$7,560	$5,400 $5,400	$6,840	$8,790	$6,300 $6,300	$8,100
Fuel or power	4,320	11,016 5,508	1,620	8,640	33,048 16,524	4,590	12,960	55,080 27,540	7,560
Depreciation 5 per cent	295	190 190	350	800	515 515	1,050	1,150	750 750	1,500
Repairs 7 per cent. annually on oil engines and steam plants, 3 per cent. on motors	413	114 114	490	1,120	309 309	1,470	1,610	450 450	2,100
Total Annual Expense (exclusive of interest)	$9,708	$14,200 $8,692	$6,420	$18,120	$39,272 $22,748	$13,950	$24,510	$62,580 $35,040	$19,260

Where the plant uses the street current in a motor, allowance must be made for loss in the motor and line. Taking the total loss between the switchboard consumption and the actual power supplied to the drive (at which point comparison should be made) as 12 per cent., we have one horsepower at the drive equal to $\frac{746}{1{,}000 \times 0.88}$ = 0.85 kw. (approximately) at the switchboard.

This basis has been adopted in the tabulation. Electric rates of 1 and 2c. per kw.-hr. are used, although

with a 100-hp. plant it is seldom possible to obtain a rate as low as 1c. per kw.-hr. Sometimes central stations offer a 1c. rate to desirable users who require power at those times when the load curve will be most benefited. Such a case is an ice or refrigeration plant, which needs a maximum amount of power in the summer with little or no load in the winter when the central station is pushed to its utmost capacity by the lighting load. General power plants cannot be considered so favorably, and the average rate would be nearer 2 to 4c. per kw.-hr.

The 100-hp. steam plant is figured with a simple engine, while the larger units are assumed to be compound condensing. Fuel consumption for everyday working conditions is represented and not the best possible performance under test. In the calculations for operation during the day only, 10 per cent. has been added for stand-by losses in the steam plants.

Daily operating expense in the first lines of the table is based on full 24-hr. operation. Yearly summaries on four different bases follow. The first two represent operation during the day only for comparatively high and low load conditions. In these two instances only half the labor included in the full daily operating expense is covered.

Daily operating expense alone is misleading, and only by estimating operating and maintenance cost for an entire year is a true comparison arrived at. A careful study of the table will prove this contention beyond any question. Depreciation is calculated throughout at 5 per cent., which will be enough for complete replacement within 15 or 20 years. Repairs are naturally higher with the steam- or oil-engine plants than the electric drive and have been figured accordingly.

Interest on the Investment To Be Added

Interest is omitted because this will vary according to the locality and the business. It is better to calculate the yearly saving possible with the more economical plants and then judge of their value. An additional investment of $10,000 in machinery that will not pay for itself in four or five years would not usually be considered. Oil-engine manufacturers often find it difficult to effect sales when the total cost may be saved in two or three years. Sometimes this is due to lack of spare capital for refinements or the reluctance on the part of investors to invest in more expensive equipment.

The estimated initial investment is expected to cover merely the mechanical equipment delivered and erected and is necessarily an approximate average. By using the table as a guide and at the same time securing accurate quotations with correct figures at hand concerning the costs of fuel and labor, a proper comparison to suit particular conditions will be determined. The cost of building might also be introduced, as this will vary with the form of power. Incomplete calculations, such as taking the difference between the initial investment involved by two kinds of power plants and then attempting to find the most advantageous in a piecemeal manner, should always be avoided. This is often done with inaccurate results and consequently unfair discrimination. Let the whole year basis be followed out and a true viewpoint obtained.

The worst offenders as a rule are central-station men who are so enthusiastic over electric power that power users are often persuaded to buy current when it really means hundreds and perhaps thousands of dollars annually expended which could be saved by another form of power. There are many plants running under conditions that favor motor drive, provided the rate is low enough, as the table indicates, but those that can be conducted on a much more economical basis by steam, oil engine or some other prime mover should be left to select what is best for them.

[The reader's attention is called to the fact that, owing to the greater initial cost of the oil engine, inclusion of interest charges would increase the proportionate total annual expense of such a plant—Editor.]

The Central Station and the Stationary Engineer

By D. A. Early

With the activities of the large central station in its sale of electric energy another stage in the evolution of the stationary engineer seems to be near. The writer has had experience in the power plant and also in selling power from the central station to large and small power users and has seen numerous isolated plants shut down. In some cases the engineer was discharged, and in others his services were retained and his status changed, usually improved.

Most stationary engineers have heard repeatedly the warning that the central station has technically trained men, for the purpose of extending its business, which means eliminating the engineer and shutting down the engine that he may have been with for years. But the salesman or the solicitor is not the only highly trained man in the employ of the corporation.

The methods of the large company are about as follows: Starting with the coal pile, the coal is bought on a heat-unit basis, and an expert is employed to test the coal. This coal tester may be a young college graduate, paid sometimes less than a stationary engineer; but he is an expert in his line just the same, so the corporation pays only for the heat energy stored in the coal. The large plant is always located where water in abundance is available, but often before entering the boilers this water needs to be put through a special water-treating apparatus which is inexpensive to operate, although somewhat costly to install, and its first cost makes it prohibitive to a small plant. The central-station boilers are of the most economical types and sizes. As every engineer knows, there are certain conditions—a certain load, a certain draft, etc.—under which a boiler produces steam most efficiently. Studies of these conditions are made by an expert, and the boiler is operated as nearly as possible under those best conditions. Although the central station has a varying load throughout the day and throughout the year, the combination of boilers that makes for the greatest economy in any particular circumstances is used. The company knows from its reports and records how often a boiler should be shut down and gone over—not every six months or every year, because that has been the custom, but when that boiler *should* be cleaned it *is* cleaned.

In the engine room the large unit has replaced the small, and the turbine the reciprocating engine, all tending toward cheaper production; and an expert sees that these units are working efficiently. There are usually enough units in the power house so that they may be

operated at the most economical load. The cost of these refinements in the central plant is a small per cent. of the total as compared with the expense for the isolated plant. The cost of the power for the average manufacturing plant is from 2 to 5 per cent. of the cost of running the business, while in the case of an electric company the cost of making the energy, or cost of production as it is called, is anywhere from 35 to 60 per cent. of the total expense.

Until comparatively recently the central-station managers did not fully appreciate the benefits to be gained from the sale of what is called the "off peak" current—namely, that current which could be generated during the day by the use of machines that would otherwise be idle—but they were most diligent in promoting the lighting business and pushing the sale of current at top prices. The result of this was that during the course of a year the power plant would generate about 15 or 20 per cent. of the energy it was capable of, although for a few minutes during the evening "on the peak" every machine might be groaning under a heavy overload. The interest on the money invested in the plant went on just the same during the period when a part of the plant was idle. The central-station men now fully realize the importance of this off-peak business and are making very attractive rates to supply the power for manufacturing.

Method of Making Rate Schedule

In the preparation of these low-rate schedules the investment in the plant, cost of production, load factor and many other items should be taken into consideration. One central station in making up its schedule for wholesale power rates ascertained the power costs of a great number of industrial plants, and rates were then made low enough to beat these costs sufficiently to get the business. It was up to the production and operating departments to produce the power cheap enough to make a profit. That central station is shutting down many small plants and still profiting by the sale of current.

As to the engineer and his job—when a power salesman submits his proposition, he is often met with one of two statements: "If I could only get rid of that man in the engine room, things would be a lot better," or "Well, my engineer has been a good man and has worked faithfully for me for 10 or 15 years; what shall I do with him? I can't afford to pension him, and I don't want to let him go."

The reply to the first is that the employer cannot afford to have such a man around, and that if he really wants a good engineer he can get one, if he is willing to pay the price. To the second, if the engineer has not produced power as economically as is possible, he has not served faithfully at all. If on the other hand he has had the ability to operate successfully so vital a part of the business as the power plant, the employer cannot afford to let him go; in fact, he would be losing money by so doing. When power is purchased from the central plant, the engineer is relieved of the care of the engine and of a large part of the boiler plant. Let him devote one-half the care to the new condition that he has to the engine, and he will produce results in the form of increased output and smooth operation of the works as a whole that are far more profitable to the owner than is the operation of the little engine.

The writer has yet to see one good engineer discharged as the result of the firm's purchasing power, and engineers are doing cleaner and more agreeable work as a result of the change. What then shall the engineer do? When the solicitor presents his estimates and figures, he may be right; then again he may be wrong. The engineer should understand his employer's business well enough to know whether the central-station man's figures are right or wrong and be able to prove it to the satisfaction of his employer. But if the central-station man is right in his statements, it is best that the engineer should be the one so to advise his employer.

If power is purchased, the following are a few of the matters that the engineer is more competent to handle than anyone else: First, there is the heating in winter; what pressure will be most economical and still give satisfactory warmth all over the buildings? Will it be necessary to add heating surface to the coils? Then comes the installation of the motors; and after the factory is operating with motors, instead of watching steam pressures, the engineer watches the voltage. Low voltage means slower speeds at the machines. If this condition prevails, is it the fault of the central station or of the wiring in the plant? The daily reading of the meter and a proper understanding of the contract under which the current is purchased; maybe changing conditions will entitle the user to a better rate. Checking the monthly power bill is another duty. If the power is purchased on a maximum-demand basis the demand should be checked; then the speed of the lineshafts and the speed of the machines; perhaps some of them can be speeded up to advantage. There are numerous other things about an electrically driven plant that would make the engineer not only handy, but a necessary man to have around.

Making 12-In. Ice in Two Hours

M. Schilde, a refrigerating engineer of New Orleans, La., has patented recently a process of making ice from raw water in a way that greatly shortens the time of freezing. According to the inventor, a block or plate of ice 12 in. thick can be built up in an hour or two, as compared to 36 to 40 hr. for the can method, or seven days and nights for the plate system.

The water, which is preferably precooled, initially flows in sheet form down a surface that may be cooled by brine circulated on the other side. The refrigerant, gas or air, acts directly on the surface of the water to produce the ice; and as the flow of water and the current of refrigerant are maintained, the ice will progressively build up until the desired thickness is obtained. It will thus be seen that the refrigerant at no time acts through a thickness of ice, so that the last inch of ice freezes as fast as the first.

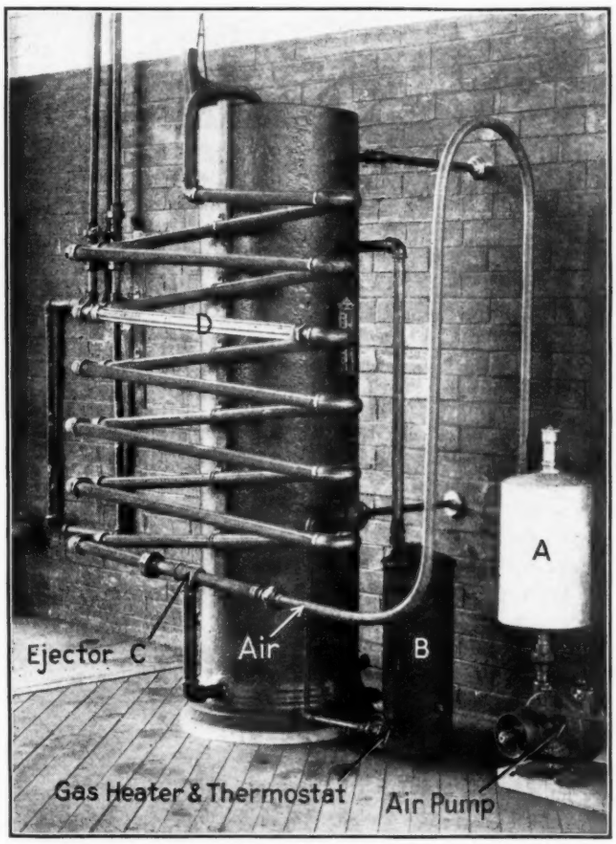
It is preferable to maintain a continuous flow of water in excess of the freezing capacity of the refrigerant, so that the surplus will carry away impurities that might otherwise freeze into the ice. This tends to produce a hard, clear and pure ice.

The Condition of Individual Fires cannot be judged with the naked eye. Some sort of colored glass (not spectacles) in a suitable frame, and hung directly where it is to be used (near the observation door), gives the operator a better means of judging the thickness of fires, movement of the fuel bed and the presence of holes or dirty places, so that he can juggle the rate of supply of fuel and air to maintain a uniform thickness of fires as necessary to give the best furnace conditions.—Sibley Journal of Engineering.

Testing the Durability of Pipe Under Corrosion*

By F. N. Speller

All will agree that a service test, or at least a test under service conditions, is the only reliable method for determining the relative durability of iron and steel products. However, to be of any value it must be possible to carry such a test to conclusion in a reasonable time. The so-called "acid test" quickly attracted atten-



APPARATUS FOR CORROSION TESTING

tion, but as this proved to be misleading the effect has been to discount any attempt to accelerate corrosion. Nevertheless, there are certain conditions commonly found in service where pipe is subject to aërated water at a temperature of 140 to 180 deg. F. under pressure, where corrosion is very severe. The method of testing here referred to works under such conditions, which are more or less common to all water and steam-pipe service.

The main factors controlling corrosion in pipe are: (1) The amount of free oxygen in solution in the water; (2) the volume of flow, which is an important factor, mainly on account of the greater amount of oxygen available; and (3) temperature. Corrosion increases with the temperature, reaching a maximum somewhere between 160 and 180 deg. F.

These conditions are reproduced in the apparatus herewith illustrated. This consists of a tank or reservoir open at the top, which may be filled with a supply of any kind of water selected for the test. This water is maintained at any desired temperature by means of a small gas heater B fitted with a thermostat, or a steam coil may be inserted if more convenient. An ejector is provided at C and operated by air under 3 or 4 lb. pressure after it has passed through a tank A containing excelsior or similar material to remove oil. The heated water is thus aërated, forced up through the coil of pipe and discharged continuously into the top of the tank. The coil consists of alternate lengths of the materials under test. A glass tube, as at D, may be inserted in the coil if it is desired to observe the flow. By keeping up a continuous flow in this way at a temperature of 160 to 180 deg. F., the relative tendency of pipe to corrode may be determined in three to four months. The amount of corrosion found in that time with this apparatus will be equal to about two years under the same conditions in actual service.

The acceleration of corrosion in the apparatus is principally due to the continuous flow and the greater amount of oxygen and carbonic acid which is thereby brought into contact with the interior surface of the pipe. The details of the machine may be altered according to local conditions. If the water is not fresh and almost pure, the supply should be renewed from time to time.

The amount of corrosion in both wrought-iron and steel hot-water-supply pipe, as measured by the depth of pitting, will frequently amount to about 0.1 in. in two years. We have found with the apparatus described nearly that amount of corrosion in pipe of this kind in three months, with the water circulating at the rate of one to two gallons per minute. The relative depth of pitting is apparently the same in each case.

The writer has used this scheme for two years in research work on the improvement of pipe and pipe coatings, with much saving of time compared with similar tests on pipe in actual use.

*Presented at the nineteenth annual meeting of the American Society for Testing Materials, Atlantic City, N. J., June 27-30, 1916.

Indirect-Acting Economizer

By B. N. Broido

The cast-iron type of economizer used throughout America, with very few exceptions, is ideal for service where the feed water is good and has a temperature of at least 80 deg. F. when entering the economizer. For plants, however, that do not use warm feed water, or where the water is very hard, the cast-iron economizer is not best suited: First, because water of a temperature lower than 80 deg. F. keeps the tubes cool where it enters the economizer, causing the outside of the tubes to sweat or condense the steam in the flue gases. This and the surrounding high temperature cause a rapid corrosion of the tubes. Second, because hard water forms in the tubes a scale which is difficult to remove and which greatly diminishes the efficiency of the economizer. To overcome these difficulties a type called the indirect economizer is often used in Germany, giving satisfactory results.

The illustration shows this type connected with a B. & W. boiler. The economizer consists of a shell A with a copper pipe coil B inside and a system of seamless-drawn, mild-steel pipe bends C in the smoke breeching. The boiler feed water passes through the heater and in contact with the copper coil. The steel and copper pipe coils are first filled with water condensed from steam and therefore free from scale-forming matter; and it remains there indefinitely, as the coils are connected together and the

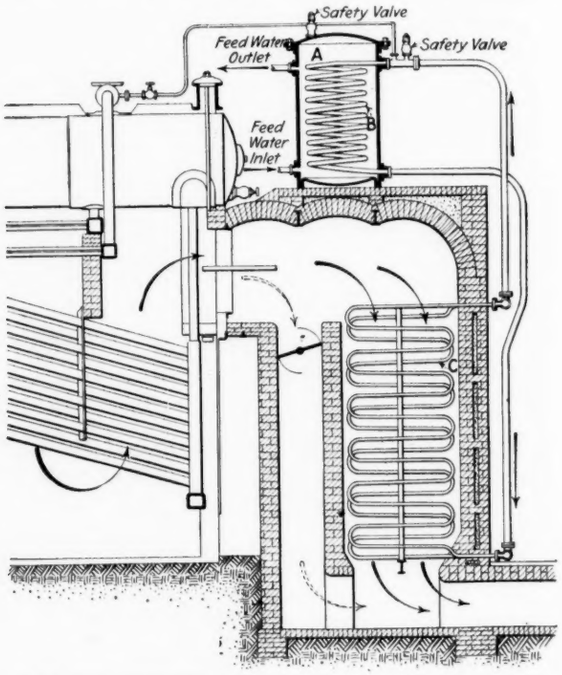
water simply circulates through them when the economizer is in service.

The action of the economizer is as follows: The water in the economizer tubes absorbs heat from the flue gases and ascends into the copper coil, where the heat is in turn absorbed by the feed water in the heater; the circulating water in the coil cools and flows down to the flue pipes, where it is again heated and rises to the pipes in the heater. The tubes remain perfectly clean inside, and there is no corrosive effect in them.

The water circulating in the economizer is always hot enough so that no condensation will form on the outside of the tubes and cause rust. Any soot and ashes that accumulate are easily removed when cleaning the boiler tubes and by the same means.

The writer once inspected an economizer of this type, which had been in operation about nine years, and found the tubes to be entirely free of any deposit, corrosion or scale.

The copper coil becomes covered with scale, but this is easily removed by raising the copper coil from the heater



TYPICAL INDIRECT ECONOMIZER INSTALLATION

and passing steam through the pipes, causing them to expand a little, thereby cracking the scale.

In order to keep the circulating water in the economizer under the same pressure as the boiler, to heat it to approximately the same temperature and to make up the evaporation, the highest point of the economizer tubes is connected with the steam space of the boiler by a small pipe that keeps the tubes continually filled with water, in case of leakage. As the economizer has no moving parts, it needs no power or frequent attention, and there are no operating expenses.

The disadvantages are: The initial cost is higher than for the cast-iron type; and as the transfer of heat from the flue gases to the feed water is carried out indirectly, there is a greater difference in their respective temperatures, or with the same flue-gas temperature feed water may be heated to a higher temperature with the direct economizer than with the indirect type. However, the temperature of the flue gases leaving the boiler is much higher than that of the water or steam in the boiler and therefore hot enough to transmit sufficient heat to the feed water by the indirect system.

The economizer shown in the illustration, attached to a 320-hp. B. & W. boiler, had approximately 1,800 sq.ft. of heating surface in the flue, and the copper coil in the heater had about 300 sq.ft. The cost of the economizer, as shown, erected in Germany about 3 years ago, was approximately 9,000 Marks (about $2,250). It heated the feed water from 120 to 220 deg. F., while the boiler was being operated at its rated capacity.

Lubrication Under Conditions That Are Abnormal

By G. C. Long

In a plant of a phosphate mining company a cross-compound condensing engine of the Lentz type, 25 and 30 by 42 in. with a piston travel of 820 ft. per min. (rated 1,500 hp.), operated from full load, with a steam pressure of 5 to 15 lb. gage in the receiver to no load with a vacuum of 5 to 10 in. in the receiver, which of course meant the same or higher vacuum in the low-pressure cylinder.

With a pressure above the atmosphere, lubrication was easily accomplished by the use of a good grade of compounded oil; but as the no-load periods were frequent and of two or three hours' duration, considerable wear developed. Different oils were tried; but as soon as a vacuum developed in the receiver, trouble commenced.

After considerable experimenting the following combination has given excellent results: One quart of the Standard Oil Co.'s "600 W" cylinder oil is thoroughly combined with three quarts of the same company's "Renowne" engine oil. A small ice-cream churn is used to combine the two oils thoroughly, and a sample of the mixture shows no evidence of separation at the end of four months.

Baffling Causing Fire-Doors To Burn

By F. C. Torrance

The writer recently had occasion to locate the cause of a peculiar trouble that existed in two Stirling boilers fired with coke breeze. These units were equipped with automatic forced draft, so that when the boiler pressure was low the fires were automatically forced, and as soon as the pressure reached the required point the blowers were shut off.

Trouble was experienced keeping the firing doors on the boilers in repair. The door linings and sometimes the doors would burn out in two days' time, and it kept the fireroom force busy making repairs. At times, when coal was used, even the door frames would get red-hot. Also, whenever the boilers were fired with coke breeze, a long flame would shoot out of the door after the firemen had shoveled in the fuel. At times this would come out far enough to be dangerous.

At first the experiment of cutting down on the blowers was tried. This, however, was found to be insufficient unless the blowers were almost shut off. Next a series of draft readings was taken. Starting at the stack, readings were taken at the following places: Stack, top of third

pass, bottom of second pass and top of second pass. These were taken both with the blowers on and with them off. The results are shown in Fig. 1. A study of these curves reveals the following: From the stack to the top of the

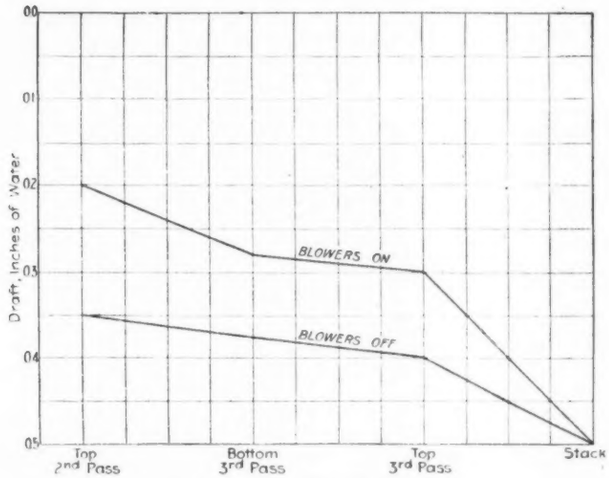


FIG. 1. DRAFT AS FOUND

third pass there is a loss of draft amounting to 0.2 in. of water; from the top of the third pass to the top of the second pass, or through two passes of the boiler, there was a drop of only 0.1 in. The readings were taken when the fires were being forced. After the blowers had been shut off, a second set of readings was taken and it was found that the loss from the stack to the top of the third pass was only 0.1 in. of water, while the loss from the top of the third pass to the top of the second pass was only 0.05 in. An analysis of the loss of draft between these curves shows that the stack and the top of the third pass is much out of proportion when compared with that through the last two passes. This loss of course could be due to only two things—either the damper was partly closed or obstructed in some other way or else the opening for the passage of gas at the last baffle was much too small. In this instance the latter was found to be the case.

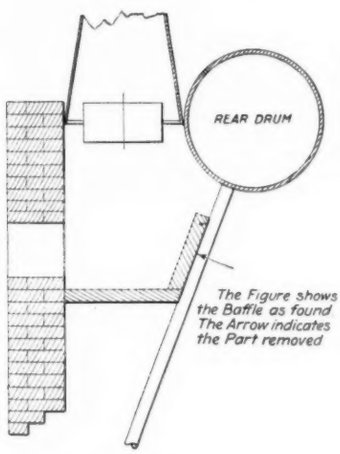


FIG. 2. TOO MUCH BAFFLE

As soon as possible an examination was made. The damper was found to be wide open, but when the boilers were installed the rear baffle under the damper had been put in, as shown in Fig. 2. This left the gas passages too small for the gas that had to go through, and the result was that the heat given off when the fires were forced was thrown back into the furnace and against the firing doors instead of being carried up into the tubes. The baffle tile leaning against the tubes, as shown in Fig. 2, were removed and another set of draft readings taken. This time readings were only taken when the fires were being forced. The result is shown in Fig. 3. The draft loss between the stack and the top of the third pass was only 0.14 in. of water, while the loss from the top of the third pass to the top of the second pass was 0.06 in.

Since the alteration was made, there have been only two changes made in the doors and these were on doors that were practically burned out at the time the baffle was changed. A marked change was also noted in the flame at the firing doors when firing the breeze. There is now little if any flame at the firing doors.

The experience cited serves to show that the baffling of any boiler must be made to suit the particular operating

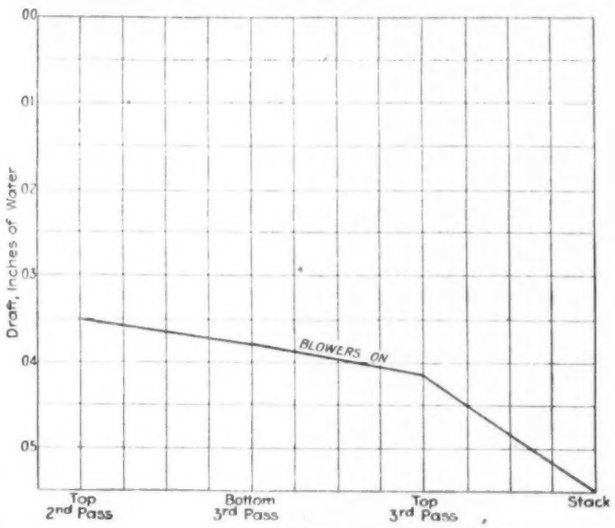


FIG. 3. DRAFT LOSSES AFTER CHANGES

conditions under which that boiler is placed, and the only way this can be accurately done is to take draft readings and then make adjustments accordingly.

Noises and Vibration

By E. C. Parham

One of the advantages of having actual experience with any type of electrical machine is the becoming familiar with its characteristic noises. Nearly all standardized machines, when in operation, are characterized by what might be called standard noise, and there are many instances where ability to note a change in the character of the noise emitted by a machine has very much helped men to locate trouble. As instances, the following may be interesting:

The owner of a lumber mill bought a second-hand continuous-current generator. After he had made a very good job of installing it, he was unable to make it generate. Being familiar with most of the more common irregularities of such machines, he checked everything as far as he could, but to no avail. He then enlisted the aid of a young engineer, but to no purpose. The lumber man was extremely anxious to get what he had paid for, so he called on the original makers of the machine for help. An inspector was sent. As soon as he heard the machine come up to speed, he knew that the seat of the trouble was vibration; on pressing the brushes of two holders down on the commutator the machine began to generate at once. Vibration was preventing the brushes from making continuous contact with the commutator and was due to an unbalanced pulley that had been adapted to the armature.

In another instance an inspector was sent to find out why the belt of a motor-driven water pump could not be kept on the pulley. He started the motor, and the noise and vibrations at once suggested that the speed was high. The motor was three-phase induction, and the only things that could make the speed of such a motor too high were excessively high frequency and the wrong number of poles in the motor. It was evident that the frequency could not be very far wrong, because other motors on the same circuit were giving no trouble. A glance at the nameplate of the motor revealed the source of irregularity—a 25-cycle motor was being operated from a 60-cycle circuit. The motor was a borrowed one, and the lender had sent one for the lower frequency.

Coke-Oven Gas as Fuel

By A. W. Morgan

SYNOPSIS—The Toledo Railway and Light Co. has contracted to burn under its boilers 9,000,000 cu.ft. of coke-oven gas per day. Best results were obtained by burning it in combination with coal fed into the furnace on a chain grate.

In adopting coke-oven gas as a fuel in its Water Street power house the Toledo Railway and Light Co. has made an innovation in current practice and incidentally has brought forth a novel scheme of burning this fuel. Due to the lack of boiler capacity caused by inability to install boilers fast enough for the ever increasing load, the engineers of the combustion department of Henry L. Doherty & Co. were called upon to develop a scheme for burning the gas which would give flexibility of operation, maximum capacity and best economy.

The gas was to be burned under six Type S, 475-hp. Stirling boilers equipped with Type K Green grates,

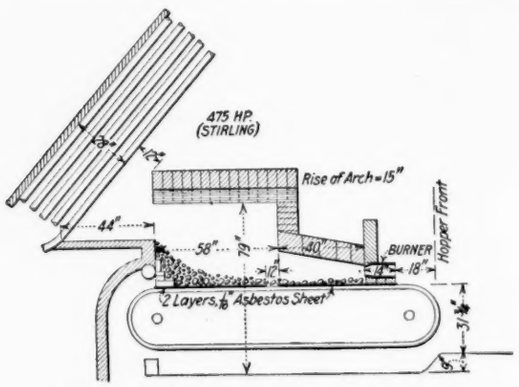


FIG. 1. ARRANGEMENT FIRST TRIED

which, due to the limited area, could not be pushed to much over rating. In equipping the boilers the grates were covered with sheet asbestos, except a space 12 in. wide, which was left uncovered for a secondary air port. As shown in Fig. 1, the front of this air port was 40 in. from the burner tips and flush with the nose block of the ignition arch. Over the entire surface firebrick crushed to the size of an egg was spread in thicknesses of about 2½ in. at the burner tips to 7 in. at the bridge-wall. This deflected and rounded the flame so that it would not strike the tubes directly.

The burner consisted of a 6-in. air mixer, 14 in. long, swedged down to 5 in. at the outlet. Gas was delivered to the burner through a 1½-in. pipe capped at the end and projecting into the air mixer about 4 in. In the face of the cap seven ⅜-in. holes were drilled, one in the center and six equally distant on a 1-in. circle. This arrangement was highly successful for capacities under 200 per cent. of rating, but would not do for higher capacities and it was not as flexible as desired.

To increase the capacity the grates were removed, and one boiler was equipped with a dutch oven (see Figs. 3 and 4). It was then easy to get 1,250 hp., or 263 per cent. of rating, and the boiler has been operated continuously at 210 per cent. of rating ever since. However, the installation was absolutely inflexible, so but one boiler was equipped in this manner.

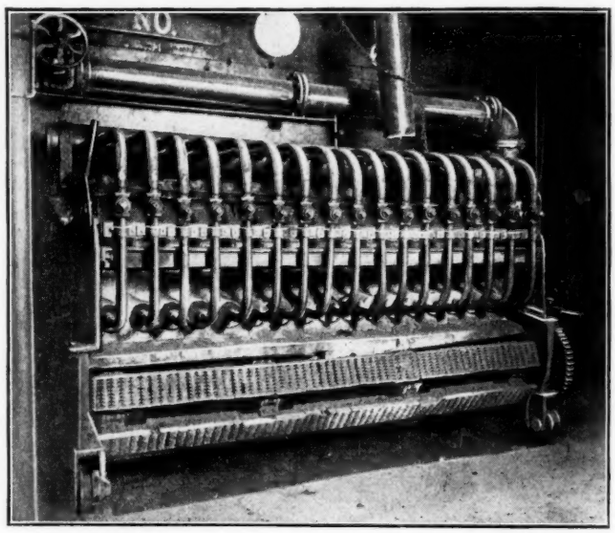


FIG. 2. BURNER INSTALLATION WITH GRATES IN PLACE

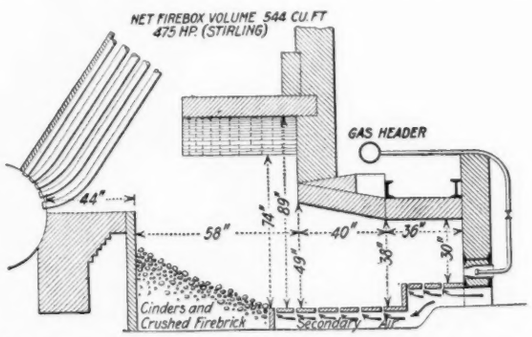


FIG. 3. GRATES REMOVED AND BOILER EQUIPPED WITH DUTCH OVEN

The plan that seemed to offer the best solution of the problem was to burn the gas directly above the coal and in combination with it. Some of the best engineers of

the company said it would not work, but the combustion department had faith and went ahead on this basis. A special tile with a 5-in. hole was developed and set so that the gas when introduced into the firebox was directed down against the coal. This tile was placed in the ignition arch next to the grate, as shown in Fig. 5. The gas was conducted to it by a 1½-in. pipe and cap drilled in the manner previously described. All primary air was shut off and the gas introduced into the firebox, using

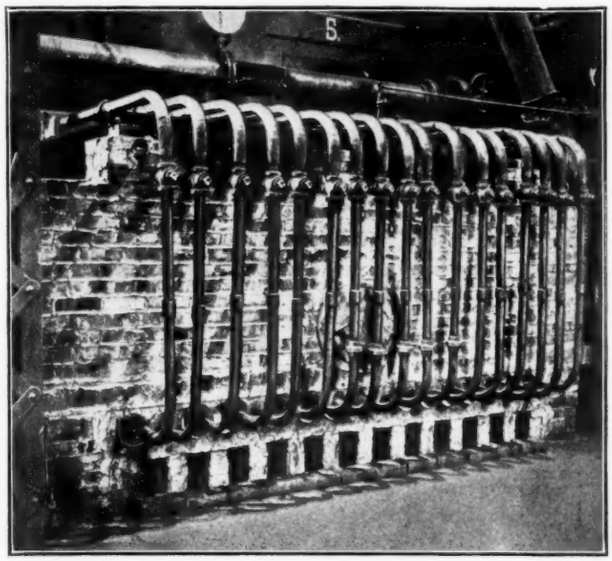


FIG. 4. BURNERS SERVING DUTCH OVEN

the secondary air coming through the fuel bed for combustion. The boiler used for this experiment was a 425-hp. Heine equipped with Green grates. It was on the low-pressure end of the plant and could be spared. No attempt was made to determine ratings, but the gas was accurately metered and the flue gases were analyzed. These data are given in the accompanying table.

Depth of fuel bed, in.	4⅞	4⅞	4⅞
Width of chain grate, ft.	10	10	10
Chain speed, ft. per hr.	16	22.5	25
Grate surface per hour, sq.ft.	160	225	250
B.t.u. in gas.	600	600	600
Analysis of gas:			
H_2	50.3	50.3	50.3
CH_4	31.1	31.1	31.1
C_2H_4	4.2	4.2	4.2
CO	6.9	6.9	6.9
O_2	0.4	0.4	0.4
CO_2	2.0	2.0	2.0
N	5.1	5.1	5.1
Ultimate CO_2, per cent.	10.9	10.9	10.9
Gas used per hour, cu.ft.	38,400	32,300	25,500
Flue gas analysis:			
CO_2 per cent.	11.0	12.5	13.2
O_2, per cent.	4.8	3.5	2.8
CO, per cent.	....	....	....

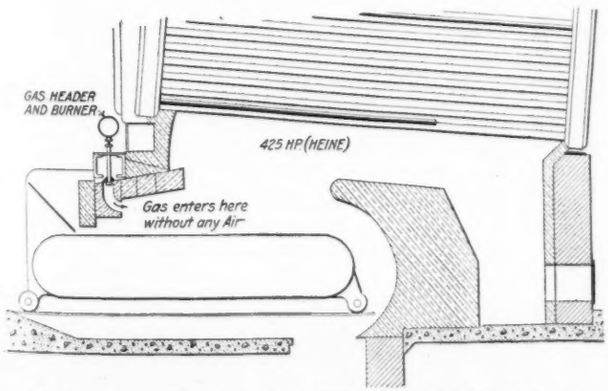


FIG. 5. BURNING GAS IN COMBINATION WITH COAL

When the gas is fired above the coal the entire firebox is completely filled with flame so intense that it is impossible to see through it even with the aid of a blue glass. As the gas runs high in hydrogen its combustion is rapid,

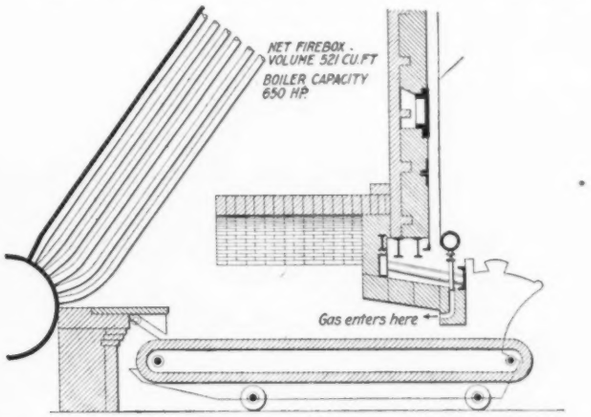


FIG. 6. COMBINATION BURNING UNDER STIRLING BOILER

so that it is an ideal fuel for combination burning. Another successful feature of this combination is the fact that there is practically no combustible in the ash, even when the chains are running at maximum speed.

On the strength of the results obtained from this boiler, equipment has been ordered and is now being installed in the 16 Stirling boilers comprising the high-pressure end of the boiler room. Fig. 6 shows the new arrangement adapted to a Stirling boiler. This design will give absolute flexibility of boiler operation, added capacity by burning the gas in addition to the coal, and higher economy because no combustible reaches the ashpit.

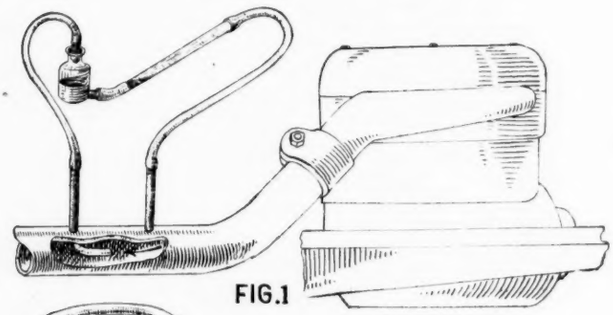
Upon the completion of this work, evaporation tests will be run and the more complete data will be published later.

Caution in Use of Pitot Tube

By L. A. Nilson

In the use of a pitot tube to determine, even roughly, the average velocity of a gas undergoing rapid fluctuations in pressure, such as obtains in the exhaust pipe of a gas engine, or air supplied by a reciprocating air compressor, care should be taken to consider the effect that such pressure variations have upon the accuracy of the instrument. A short time ago the writer, in order to ascertain approximately the velocity of the exhaust gases from a large six-cylinder automobile engine, installed a small dynamic tube and a piezometer tube connected in the usual manner to an inclined manometer, as shown in the illustration, Fig. 1. Contrary to expectations the reading was negative; that is, with connections as shown, the water column in the inclined tube went down, which seemed to indicate that the static head was greater than the dynamic head. A larger dynamic tube and new rubber hose failed to make any appreciable difference, but when the inclined manometer was replaced by an ordinary U-tube the water column moved in the proper direction and read consistently higher with increased engine speed. The smaller dynamic tube was then tried with the U-tube manometer, and it still failed to give positive results. The following reasoning will explain these paradoxical occurrences and prove the impossibility of getting reliable results with such an arrangement.

Imagine what might happen if the U-tube manometer is connected up substantially as shown in Fig. 3, so that the pressure from the pipe is free to act on both sides of the manometer simultaneously, but one side of one manometer has a larger air capacity above the liquid than the other, as was the case with the inclined manometer that proved unsatisfactory. With a uniformly steady



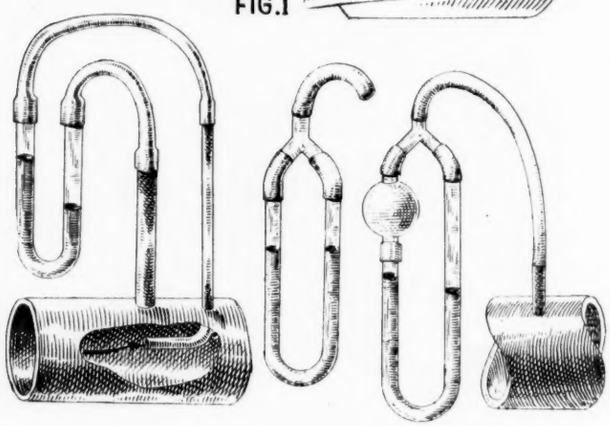


FIG. 2 FIG. 3

EXPERIMENTAL PITOT TUBE CONNECTIONS

pressure, it is obvious that the water column will stand at the same level on the two sides in either case; but when a uniformly fluctuating pressure is applied, as from the exhaust pipe of the automobile engine, the comparatively large volume of air on the one side acts as a cushion to absorb the shock, much the same as a rubber ball would absorb the blow from a hammer, while the sudden pressure rise acts more directly upon the water column on the other side and forces it down. Any difference, then, between the volumes of the inert gas above the liquid in the two sides of the manometer will tend to produce the effect shown and make the pitot-tube determinations of no value.

Another source of error, besides the volumetric difference, may lie in a difference between the frictional resistances of the two tubes. To illustrate: Take a small and rather lengthy dynamic tube, together with a much larger static connection, as shown in Fig. 2. According to the preceding discussion, the static side having the larger air capacity should absorb the pulsations and produce a less effective pressure on the surface of the water column on that side. It was found, however, that a directly opposite effect can be produced, because of the frictional resistance imposed upon any movement of gas in the small tube, such as occurs from a sudden increase in pressure tending to compress the long slender column of air shown.

This proves that the pitot tube is impractical for measuring the velocity of gas subjected to frequent and sudden pressure changes, and that in any case the connections should be short and of the same length and as nearly uniform as possible, in order to transmit the pressure changes quickly and accurately; also, that inclined manometers or draft gages should not be used.

JUST FOR FUN

He Works Upon His Auto All Day

[It is not often that we publish an anonymous communication. We do so in the following, as the little ditty aptly portrays how an engineer may become absorbed in a hobby to the detriment of his work.—Editor.]

Our chief has got an auto, just as bright and slick as new,
And it stands there by the work bench, proud and gray;
It has headlights, a magneto and a battery or two,
With a big, loud screech to scare the kids away.
He is thoroughly acquainted with its every bolt and screw
And has memorized the road bumps all the way;
But he keeps the close air tainted with the fumes so thick and blue,
While he works upon his auto all the day.

There's spontaneous combustion at the bottom of the bin,
And the smoke rolls out around the boiler room,
Where the firemen are hustling, trying hard to shovel in
Coal enough to make the lights shine through the gloom.
Half the boiler tubes are blistered, and the costly vapor sings
Through a hundred leaky gaskets on the line;
But the poor chief has no chance to see what's happening to things,
For he works upon his auto all the time.

He adjusts his carburetor every morning up to scratch,
So his auto takes but little gasoline;
But the Orsat's dry and dusty and the boiler setting's cracked,
And the coal bills make the poor directors scream.
He has laid off all the oilers, for the payroll seemed too high,
Now the shift man does the wiping his own way;
But the boss has kept his helper, for it's good to have him nigh,
As he works upon his auto all the day.

Heav'nly Father, I'm not perfect—I've a hunch where I shall go
When I've rounded out the years allowed on earth;
But just grant me this one favor when you send me down below,
And I'll rest at ease through countless years of mirth:
If you'll give to dear old Satan, whom my boss is very like,
Such another car as yonder little gray,
I'll be sure the fire won't burn me hard enough to make me pike,
For he'd work upon that auto all the day.

Anonymous for Obvious Reasons.

Didn't Purchase Patched Boiler

A manufacturer ordered a new return-tubular boiler. The builders shipped one of the butt-joint riveted type. Imagine the boiler maker's surprise when he received a demand for the refund of the purchase price because the boiler was second-hand. Thinking that possibly a mistake had been made, a representative rushed to the manufacturer's plant to investigate. "What do you mean by shipping us an old second-hand boiler?" demanded the irate purchaser. "Come and see it! Look at those two patches you have put on!" and he indignantly pointed to the strap plates of the butt-riveted joints.

Governor Stability exists when the governor assumes a definite position for each particular speed and when a change of speed is necessary for a change of position, while a governor which is in equilibrium at but one speed is said to be isochronous. Perfect isochronism would be impractical, as the slightest increase in speed above the normal would result in cutting off the steam, accompanied by a sudden decrease of speed, following which the steam valve would open wide, thus giving rise to extreme fluctuations.

Editorials

Our Trade in Foreign Markets

Never before have the industrial resources of this country been so highly organized, which is the outcome of the numerous demands made upon us by the countries at war. The question naturally arises, What are we going to do to keep the vast industrial machine in operation after peace has been brought about? Many seem to feel that great demands will still be made upon us for materials to help in upbuilding the devastated territories, but we must not forget that the continent at war has a just as highly developed industrial system as our own, doing just the same thing that is being done in this country—namely, making war materials—and some of these countries are doing it under very adverse economic conditions, being practically isolated from the rest of the world. Therefore, it would seem quite reasonable that they will be in a position to meet their own needs to a very large extent and probably supply considerable for the needs of other countries, which means that we must look elsewhere for demands to fill.

All things considered, no other foreign country offers such opportunities for the investment of American capital and such a vast outlet for the products of our great industrial system as South America. After the war began, considerable interest was created in this direction; but under the stress of the demands made upon us by other markets offering large profits our Latin-American neighbors were again overlooked. Until recently one of our greatest difficulties encountered in competing in the South American market has been the lack of proper banking facilities, but this obstacle has been overcome by some of the leading American banks establishing branches in many of the Latin-American cities; and the end is not yet—further extensions to this system are planned.

To stimulate the confidence of the American investor in foreign projects the American International Corporation has been organized with a capital of fifty million dollars to create a responsible organization to investigate foreign propositions, to find the necessary capital to finance worthy enterprises, superintend their development and stand responsible to the American investor. One of our largest engineering firms is associated with this corporation. The outcome of all this is that large engineering and contracting corporations have also taken up the work, and contracts amounting to millions of dollars are beginning to come to this country, which is a good indication that the work is well in hand.

The Federal Government is also studying the matter, and a complete report on the markets for construction materials and machinery in South America is to be made by the Bureau of Foreign and Domestic Commerce. In its preparation a representative of the bureau will conduct an investigation covering all the southern republics. The bureau intends to offer for the benefit of American businessmen such information and recommendation as will lay a substantial foundation for trade extension in the lines mentioned. A prominent engineer has been selected for this important work. This is one of twenty important investigations to be conducted this year by the bureau in the interest of American trade.

Now that the Federal Government is lending support to this proposition and capital is being invested, with American engineers and contractors taking up the work, it would seem that the time has arrived for the manufacturer to come in and assist those already in the field to build up a lasting business in the Latin-American republics and other foreign markets. South America is a country of tremendous possibilities and almost unlimited natural resources. It possesses magnificent waterfalls, which as a whole are especially favorable for hydro-electric developments.

Since the supply of coal and oil is comparatively small in these countries, it makes the development of their water powers all the more imperative. In this one field of development alone it would seem that the opportunities are unbounded. Then there are the construction of railway and harbor improvements, the working of mines and the building of public works, such as water and sewerage systems, etc., which are shockingly lacking in many of the cities. All this will require enormous amounts of machinery and engineering materials of every kind.

Probably at first the profits from these markets may not be as large as we have been accustomed to. This is nothing more than what would be expected from any pioneer development. Large returns cannot be looked for at first; but with American capital invested and American engineers and contractors firmly established, all this will in time properly adjust itself.

There are two things in particular that the American manufacturer must not overlook if he expects to succeed in this field; namely, that the needs of the foreign market are not the same as our own and that the method of doing business in this country will not do for foreign trade. It is therefore necessary that these needs be studied and in so far as possible an endeavor made to meet them.

Accepting the Lowest Bid

It is indeed unfortunate to be so situated that equipment or supplies must be accepted regardless of value received or suitability for the work at hand, simply because they are offered at the lowest purchase price.

Not infrequently one who is conscientiously inclined will undertake to counteract the "lowest-bid fallacy" only to meet with everything in the way of discouragement from inertia to active opposition and to find that not only his judgment, but his honesty, is questioned. It requires bulldog tenacity to stick through a single case of this kind, and this characteristic must increase at least as the square of the number of instances encountered.

It may be said that specifications should be so drawn or the article so thoroughly described that there can be no deviation from the standard set without at once excluding the inferior article. This rule, however, does not hold for several reasons. The old lawyer's saying

that "where there is a will there is always a way to break it" is as applicable to specifications as to wills. Some firms, as well as individuals, apparently go to as much expense and effort to beat the other fellow as would be required to meet him squarely. There are others, not so skilled or well equipped for production as their competitors, who, notwithstanding honest intentions, produce a less meritorious article, yet by reason of the lowest-price habit and small profits manage to place their products. Then there is the well-established fact that nothing, human at least, is universally best for every service or locality.

Lack of conformity to existing equipment is a valid reason for not accepting the lowest bid in some cases. The use of a variety of equipment necessitates extra investment in spare parts and produces unsatisfactory operating conditions all around. This feature alone may justify a higher price in the interest of economy. In such cases, perhaps, bids should not be called for except from makers of the equipment already in use. This practice rules, however, only where bidders are put to considerable expense in submitting prices, for it is to the mutual advantage of maker and user to come in contact occasionally, and the cost is properly chargeable to advertising or "missionary work."

Routine Use of Indicator

The steam-engine indicator is universally recognized nowadays as indispensable in a power-plant, inasmuch as economy of operation is largely dependent upon its fidelity in revealing defective adjustments of valve and governor gearing, and internal wear and tear—all of which have a vital effect upon the steam consumption. The question as to how long an engine may be permitted to run before disorders calling for application of the indicator might be expected to develop is therefore not an unusual topic of discussion among operating engineers.

If this question is canvassed among engineers running a variety of engines, as to type and size and speed of rotation, a great variance of opinion will be found to exist. Some will insist that the indicator's utility is not realized to the full unless it is put into service at least once every seven days, while others will argue that it is a waste of time and energy to apply the instrument oftener than, say, twice a year, the wide differences of opinion being generally proportional to the diversity among the types of engine considered and the character of the service. The man with a frequently overloaded high-speed engine stands for the shorter interval, while one who looks after the running of a slow-speed, evenly loaded, old-fashioned engine in a mill or factory may argue for the longer.

There are many engineers who indicate their engines regularly at brief intervals simply as a matter of course—as an established event in the routine of plant operation, like the weekly winding of the clock, and the like. And as a general rule, it will be found that a man of this systematic habit keeps the slack out of the operating details of his plant so thoroughly that he will have accumulated a voluminous stack of diagrams before he finally gets one showing something amiss with the engine.

It is rare, however, to find a steam engine plant in regular service where application of the indicator every seven days or so is a necessity in securing safe and efficient running conditions. When such a situation is in evidence, one will be justified in venturing the opinion that defective design, inadequate methods or facilities for adjustment, or chronic overloading of the engine is at the core of such necessity.

Nevertheless, it is excellent practice to make the systematic indicating of the engines every little while, and the filing of the diagrams obtained, a fixed rule of the plant. It costs little or nothing, and at the same time it places the events of steam distribution beyond conjecture, so far as the engineer's knowledge of them is concerned; and besides, it is exactly in line with the methodical effort that efficiency in every field of human activity demands. Also, it may be the means of arresting an occasional small defect that might otherwise go on insidiously sapping the economy of each day's run and ultimately amounting to a serious loss in its cumulative effect.

Preparedness

The air is full of talk of preparedness, preparedness against impending disaster or possible attack. The idea is pregnant with possibilities outside of the military sense with which it is ordinarily associated.

A country that becomes involved in war must have not only ships and forts and guns and men to man them and ammunition with which to serve them, but its industries must be organized to provide for the extraordinary needs of the fighting as well as the ordinary needs of the non-fighting population. Where are we to get the shoes, clothing, blankets, provisions, saddlery, etc., to equip and re-equip a large army suddenly called into action? How are we to transport them and get their supplies to them? Real preparedness involves the working out of all these details, the study of sources of supply, of facilities of handling, manufacture and distribution, both as they exist normally and as they are likely to be affected by war conditions, and a previous determination just which way to turn, just what things to do when the crisis comes.

Such readiness may be just as important to the success of an individual as to the security of a nation. In a time of stress one man will lose his head, fail to do the thing that would minimize the trouble, and make a mess of matters generally. Another will quickly and coolly do those things which will most promptly restore running conditions with the least disturbance and damage. The second man does not think of all the resources, invent all the expedients that he turns to and makes use of on the spur of a moment fraught with peril and excitement. In fancy he has been through that or similar experiences dozens of times. He has long ago made up his mind just what he would do when this or that happened, where he would turn if the fuel or water-supply failed, how he would redispose his force in the event of injury, indisposition or defection of some of his men, how he would reduce the load to the irreducible minimum in case of the putting out of commission of most of his units, how he would get quick repairs made to boilers, engines, piping or auxiliaries, and is prepared without confusion or loss of time to meet any emergency to which his plant is liable in the best way that it can be met with the means and material at his command, organized for immediate use with all the efficiency that study, forethought and preparedness can insure.

Correspondence

Two- versus Four-Stroke-Cycle Marine Diesels

Referring to Mr. Crowly's letter in the Aug. 15 issue, I judge he has misconstrued my former comments in that it was not my intention to make propaganda for the two-stroke-cycle engine; nor did I intend a report on the maiden voyage of the "Secundus." As Mr. Crowly says, "I left off the end of the story"; but as expressed in the opening paragraph of my article, the only purpose was to answer the question raised by Mr. Lisle as to a 10-days' continuous run (24 hr. per day) of a two-stroke-cycle marine Diesel.

Mr. Crowly makes it appear that I personally am a believer in the two-stroke-cycle engine exclusively and an adversary of the four-stroke-cycle engine. On the contrary, a man who has gone through all the difficulties of the two-stroke-cycle marine Diesels during years of practical experience, and has met one trouble after another in the evolution of this type is certainly not inclined to offer at present the two-stroke-cycle engine in general as a finished product. When we thought we had overcome one defect, the next one showed up, and so on. Considering all these difficulties on the two-stroke-cycle engine and considering the unfavorable dynamic conditions as we have them in the single-acting type (hence the bearing troubles), did I not advocate in my letter the four-stroke-cycle engine up to a certain output and for certain purposes; and did I not say that if it comes to larger output, "Why not go one step further and consider the double-acting two-stroke-cycle engine?" I repeat, This engine will come, and the opponents can only delay its progress.

Here my plea for unity in engineering endeavors comes in. I did not appeal to the unity of the customer and the manufacturer. I did not say to heap the costs of experiments on the shoulders of the customer, but I appealed for the coöperation of the designing and operating engineers who are employed in this great engineering problem. The customer, as well as the cause, can be served best at present only by offering an engine that is fully proved in operation.

The Diesel engine with its higher pressures differs from a steam engine in its claims upon the designer and the shopman, which I do not think is fully appreciated. If a designer has spent, say, an hour or more every day in the shop or on the test bed for a term of years or if he has run an engine for four weeks in some plant, he often thinks he knows everything about operation and is not willing to listen to the practical man. One of the reasons for this is that many things in the shop cannot be explained as the designer would like to have them; it takes just a practical feeling. Consequently, the shop men do not stand to reason with him.

When I was a co-worker in the development of the first marine Diesel at a shipyard, an experienced and very ambitious marine engineer was assigned by the purchaser to supervise the design and the construction. He was asked for opinions on minor things, but the combustion engine being different from the steam engine, the designer thought the engineer's practical experience was worthless for this case. When the engine was put in operation, the designer was the one who had to learn. After we looked over the reports that the marine engineer had written during his supervision, an honest man must confess we could have made a better engine if we had listened to a practical man.

On the other hand, the foreman in the shop, who perhaps so far has been accustomed to building steam engines, has to have a little more belief in the designer. With this I do not mean to say, as many opponents of the Diesel engine claim, that the parts all the way through have to be machined to a limit of one-thousandth of an inch. I would not call such an engine commercial, but there are certain points that must be considered more than has been necessary in steam engineering. I witnessed a case where this was carried to an extreme. We had acquired the license from a well-known builder of Diesel engines and were told that all moving parts must fit so exactly that we made every valve and guide to recognized gages; but when the engine was put in operation difficulty was had in eliminating the troubles caused by too close fits of sliding parts.

I have just returned from a trip to the East, visiting different places where Diesel engines are built. I found in Jersey City one shop where the designing, construction and operation are all done by one person, the manufacturer himself, which is one way to find out where the Diesel engine is lacking. Consequently, this marine Diesel looks reliable. This engine is a four-stroke-cycle marine type, but some day the two-stroke-cycle marine Diesel, let us say the double-acting type, when studied, designed and constructed, taking into consideration the wishes and experiences of the designer, the shop engineer and the operating engineer, will be equally successful and, I hope, will be manufactured and operated in America.

Mr. Crowly will probably reply that coöperation will not prevent cracked cylinder heads, bearing troubles, etc. I admit this, but it will help to arouse the interest of the operating engineer, when we answer his desires. It will then make him love his engine; he will make suggestions which will help more in the development of the engine than the study and patents of ten designers. Furthermore, we have to interest the chemist and the foundryman to study the material. That is what I mean by unity and coöperation of all engineers concerned with the manufacture of Diesel engines, both stationary and marine.

Mr. Crowly attacks me mostly for my statements about the "Secundus." Here, I am sorry to state, the editor omitted a part of my communication, and consequently the impression I wanted to give about the two-stroke-cycle marine Diesels was slightly different from that given in the paper.

First of all, I think the builder of this engine never would have built a single-acting two-stroke-cycle engine

of that output, had it not been for the pressure of the shipping company, which was not willing to wait until the tests with a double-acting two-stroke-cycle engine were concluded. Moreover, it was the first marine Diesel of this builder, who developed this type with very little experience in combustion engines. This engine was built primarily without forced lubrication. Later, the operation showed it to be necessary. On the voyage they stretched canvas in front of the engine in an effort to keep the oil inside of the engine in spite of the oil guards, which were later patched on the engine. I think under these circumstances I do not need to say anything in defense of the high oil consumption, and it is reasonable to assume that the second engine would look a little different. It cannot be denied that one of the greatest difficulties of two-stroke-cycle engines has been with the bearings. This is an experience all builders of this type have had; but when checking up the bearings and considering all forces imposed on them, as acceleration forces by the masses, etc., we find that the two-stroke-cycle engines have at least 30 per cent. less bearing surface per pound pressure than any four-stroke-cycle engine. This is acting under less favorable conditions in addition, as the pressure on a two-stroke-cycle engine is acting continuously on one side of the bearing, thus making it impossible to furnish at every revolution a new film of oil between journal and bearing, as is the case in the steam engine, the four-stroke-cycle Diesel engine and the double-acting two-stroke-cycle Diesel engine.

I am sorry to say that at present we are cut off from any news about what is going on in technical matters in Europe, since technical newspapers are confiscated in England; but I think the marine Diesel has been developed during this war more than during any equal period of time in former years. Perhaps when we hear about their recent achievements our judgment may be different from what it is now.

In conclusion let me point to the Fiat marine Diesels. The Fiat-San Giorgio, of Spezia, Italy, is building two-stroke-cycle engines; judging from the orders received and the big units which they put recently into operation, the customers must have great confidence in them.

I personally wish to state that I never represented the single-acting two-stroke-cycle marine Diesels one-sidedly, but I made my statements with the idea of giving a square deal to both the four- and the two-stroke-cycle engines.

St. Louis, Mo. H. SCHRECK.

Truing Exciter Commutators

I have charge of three alternators with direct-connected exciters. My method of truing the exciter commutators is shown by the illustrations. Two fixed planes are formed by irons bent at right angles, brought over the commutator and held in position on the frame by setscrews, a part of the angle iron being cut away for this purpose, as shown. The projecting planes are made parallel with the commutator, and a slot permits adjustment. The commutator is then run at normal speed, and a flat smooth file is carefully and slowly pushed over the planes. The file cuts away a part of the planes and also the commutator.

By carefully working the file across the planes, the face of the commutator is made true. Ample use of chalk on the file will help to prevent it from tearing the copper.

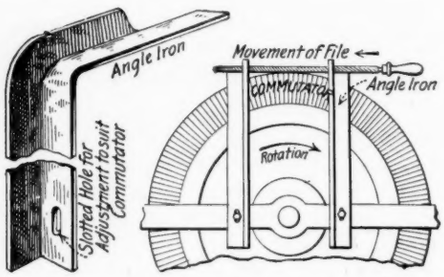


FIG. 1. METHOD OF APPLYING FILE

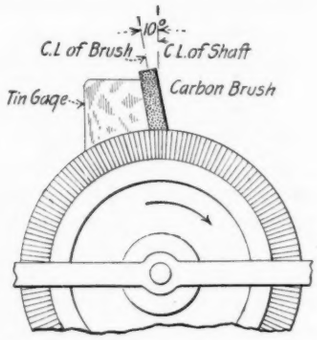


FIG. 2. BRUSH SET BY GAGE

When finishing, frequently clean the file. Use chalk, and by light, slow filing a very nice surface can be made. It will be necessary to check the filing by using a small steel straight-edge to keep the face of the commutator straight. The filing finished, take the same file and wrap around it a sheet of fine sandpaper and push it slowly over the planes, gradually moving it over the entire face. It is necessary to have the bearings of the exciter a good working fit. This method can be adopted to true any commutator by hand, and when the fixings are once made, they can quickly be put in place.

When this work is finished, I wrap a piece of paper around the commutator and make the two ends just meet, giving the actual length of the commutator, and then mark off six equal divisions for the six brushes. The paper is put back again, and the brushes are all set to an angle of 10 deg. from the periphery in the direction of rotation, by means of a gage. I carefully bed each brush with sandpaper in its own place. I have followed this procedure for the past two years, and the results are quite satisfactory. B. J. BELL.

Transvaal, South Africa.

CO_2 Recorder in Small Plants

In reply to Mr. Priefer's question in the issue of Aug. 1, page 178, as to whether it would be worth while to install a CO_2 recorder in a small plant and where it should be located, I would say that such an instrument pays for itself in time in any plant, and the length of time required depends on several conditions. Proper interpretation of readings is important.

One of the principal factors in power-plant operation is human nature. The average man grows careless at times when he knows there is no direct check on his work. It is during these spells that the "ultimate efficiency" suffers. A recorder furnishes a constant check which tends to eliminate that very human tendency—carelessness. The following facts regarding a recorder installation which came under the observation of the writer may be of interest:

The plant was averaging 9 per cent. CO_2 and was considered to be operating efficiently. A recorder costing $300 and equipped with a low-efficiency alarm was in-

stalled in the chief's office, out of sight of the men. At first the alarm bell, in the fire room, was set to ring when the CO_2 dropped below 9 per cent. Within a week the CO_2 averaged 13 per cent., making a saving of approximately 6 per cent., and the low limit was raised to 11 per cent.

The firemen were determined if possible not to ring that bell. As they did not have the chart in sight, they could not tell just how near they were to the ringing point; so in order to play safe they kept on the job, doing their best continuously. The CO_2 average was chalked on the boiler fronts every watch, to keep up interest. This experience should make clear where a recorder should be placed. The coal bill of $20 per 24-hr. day was cut approximately $1.20 per day, so that the recorder will pay for itself easily inside of a year.

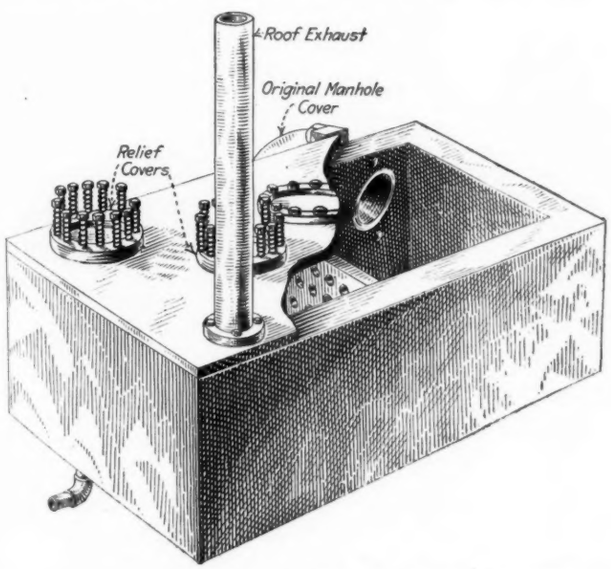
A little attention all the time instead of a lot of attention some of the time is sure to result in higher efficiency.

A. H. POHLMAN.

Brooklyn, N. Y.

Exhaust-Box Cover

The exhaust gases of a large twin oil engine were conducted independently from each cylinder through a 14-in. steel pipe to a reinforced-concrete exhaust box, or muffler, having a 24-in. manhole cover to allow for inspection. There were two baffles in the muffler to change the direction of gas travel, and two 12-in. steel pipes, 20 ft. long, led the gases above the level of the engine-room roof.



EXHAUST BOX WITH PART OF COVER REMOVED

Somehow when starting up, one cylinder failed to ignite the heavy oil, and the other side carried the load. The unconsumed oil from the first side was carried eventually to the muffler. When more load was put on the engine, it labored heavily for a few minutes and then began firing on both cylinders. After a few impulses, however, there occurred an explosion in the exhaust pipe and muffler tank, and suddenly the heavy cover came crashing through the engine-room roof.

I was called upon to design a cover for the exhaust box that would be safe under such conditions, and the sketch shows the scheme that was adopted. This cured the trouble. Although but one such explosion has occurred since, nothing was noticed except that the four covers rose to their limits and then returned to their seats without damage. The springs were light; and as there were twelve on each relief cover, they were able to dissipate the energy of the explosion.

New York City. D. L. FAGNAN.

Something About Formulas

What is a formula? Simply a rule, stated without words, in which the quantities are represented by letters, symbols or figures and all operations for solving are indicated by signs and by the relative positions of the several quantities. Illustration: To find the area of a rectangular plane a given number of feet in length designated as L and width called W. The area A is the product of the length multiplied by the width and if set forth as a formula, is $L \times W = A$, by which the area of any rectangular plane may be ascertained by substituting numerical values. If L, for example, equals 12 ft. and W 10 ft., then A (the area) will equal 12 times 10, or 120 ft.

To find the width when the area and length are known, the formula is stated $W = \frac{A}{L}$, or width equals 120 divided by 12 $\left(W = \frac{120}{12}\right)$. The value above the line is to be divided by that below the line.

In a similar manner the length may be found: $L = \frac{A}{W}$, or length equals 120 divided by 10 $\left(L = \frac{120}{10}\right)$. The act of rearranging the factors L, W and A, as shown, is called transposing and is the same in all formulas.

One of the first formulas the power-plant student meets is $Hp. = \frac{PLAN}{33{,}000}$ which, expressed in words, means that the horsepower of an engine ($Hp.$) may be found by the continued product of the mean effective pressure on the piston in pounds per square inch (P), the length of the stroke in feet or fracton of a foot (L), the area of the piston in square inches (A), and the number of strokes per minute (N); this continued product is then divided by 33,000.

A horsepower is the power necessary to raise 33,000 lb. vertically 1 ft. in one minute or any combination of feet and pounds which multiplied together to make the equivalent of 33,000 foot-pounds per minute—as for instance, 3,300 lb. raised 10 ft. in one minute, or 100 lb. raised 330 ft. in one minute, or 550 lb. raised 1 ft. in one second. Assume an engine having a mean or average pressure of 50 lb. per sq.in. acting on its piston with a stroke of 12 in. (1 ft.) and a piston with an effective area of 100 sq.in. running at 250 revolutions, or 500 strokes, per minute. The horsepower worked out with these values substituted in the formula for the symbols $PLAN$ would be

$$Hp. = \frac{50 \times 1 \times 100 \times 500}{33{,}000} = 75.8$$

This engine formula is generally met with in the form given, because it is usually the horsepower of an engine that is required, but the values may be rearranged so that any one unknown quantity out of the five may be ascertained from the four known. The simplest way to make the change is to first eliminate the denominator in the

second member of the formula, which is done by transposing the quantities in the denominator to the other side of the formula. Thus transposed it will read, $Hp \times 33{,}000 = PLAN$, and the formula is now in shape to transpose in any way desired. For instance, suppose an engine is to develop a certain horsepower and the length and number of strokes and size of the cylinder are all fixed and are represented by LAN. There remains to be determined, then, the mean effective pressure P. The constants LAN become the denominator or "the other side," and $33{,}000 \times Hp.$ becomes the numerator of the formula, after which it will read $\frac{33{,}000\ Hp.}{LAN} = P$, or $P = \frac{33{,}000\ Hp.}{LAN}$ and may be designated as the pressure formula.

Proceeding in a similar manner, to find the area of the piston in square inches, $A = \frac{33{,}000\ Hp.}{PLN}$; to find the length of stroke in feet, $L = \frac{33{,}000\ Hp.}{PAN}$; and to find the number of strokes per minute, $N = \frac{33{,}000\ Hp.}{PLA}$.

Proof: stated as an equality, the whole of the denominator multiplied by the value sought (when found) must equal the numerator, as before stated.

The transposition of the horsepower formula and that dealing with the length, width and area of a rectangular plane, as explained, involve the same principles and should go a long way in clearing up the trouble that many beginners experience when called on to use a "rule without words." The essential thing to know is what the various symbols represent in numerical quantities and the relation each bears to the others. With these fixed securely in mind and with an understanding of transposition, simple formulas should cease to be a mystery.

Washington, D. C. H. G. Gibson.

Massachusetts Board of Boiler Rules and A. S. M. E. Code

Our attention has been called to an editorial on page 135 of the issue of July 25, entitled "Massachusetts Board of Boiler Rules and A. S. M. E. Code," the spirit of which is highly commendatory, but which contains one or two statements that need qualification.

We do not know of any "repulsion between the two bodies" as mentioned in the first paragraph, for when the A. S. M. E. Code was first formulated, this board was in correspondence with the society and furnished copies of our literature (steam-boiler rules, boiler-inspection law, engineers and firemen's license law, etc.), later keeping them fully posted concerning the changes that we proposed to make in our steam-boiler rules from time to time. Our attitude has never changed, although for a long time past the A. S. M. E. seems to have delegated the Code to the care of other hands.

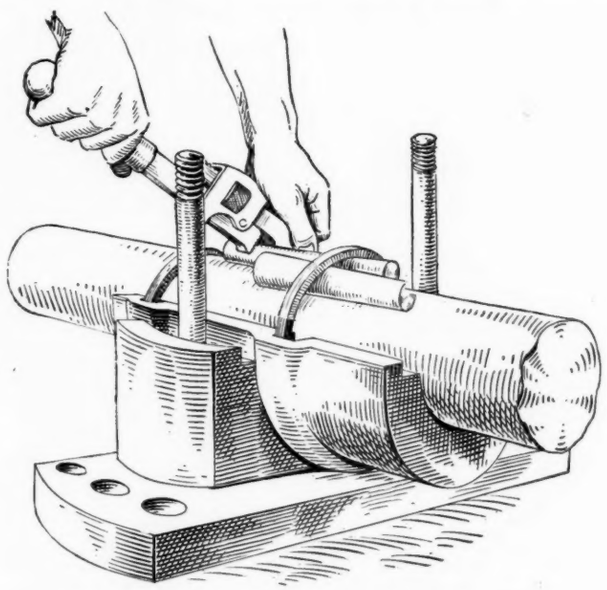
The third paragraph states that "outside manufacturers are obliged to carry special stocks and to go through a lot of red tape." A glance at the list of manufacturers authorized to construct "Massachusetts Standard" boilers shows that of the 116 manufacturers only 32 are located in New England and that 84 are in other parts of the country, notably New York, Pennsylvania, Maryland, Ohio, Illinois, Indiana, Michigan and Minnesota. No special complaint has been received by this board from any of the 84 outside manufacturers in regard to carrying special stocks or going through a lot of red tape. In fact, the only red tape is to make out the data report, etc., called for in the Rules, which is not considered a hardship.

The fourth paragraph states that perhaps the New England user of steam boilers is being exploited and goes on to aver that only a few boiler makers local to New England are equipped to build a "Massachusetts Standard" boiler. We think you will see, by comparing the 84 authorized manufacturers outside of New England with the 32 in New England, that the foregoing statement is in error.

George A. Luck,
Boston, Mass. Chairman, Board of Boiler Rules.

Truing up Oil Rings

The letter on "Truing up Oil Rings" in the issue of July 18, page 106, suggests a good way of setting right oiling rings that have become bent or distorted, but it



TENSION PUT ON RING WITH TAPERED PINS

does not always take care of the ring that has stuck in some one place long enough to wear a slight concave spot in the metal. This was done in a way that did not require the accurate preliminary fitting demanded by the curved segment proposed by Mr. Fox in his letter.

Two tapering hardwood pins were turned up, with a minimum diameter slightly less than the clearance between ring and shaft, in the position shown in the illustration with Mr. Fox's letter, and with a maximum slightly greater in diameter. The pins were then slipped under the ring from opposite sides, until the ring was pulled closely against the shaft and held there. One of the pins was then turned with a pipe wrench on the protruding end, and the ring gradually revolved around the shaft under the strain imposed by wedging the pins. After the pins had been turned until they reached the edge of the lower bearing half, the shaft was revolved enough to present another segment on which to work the rollers.

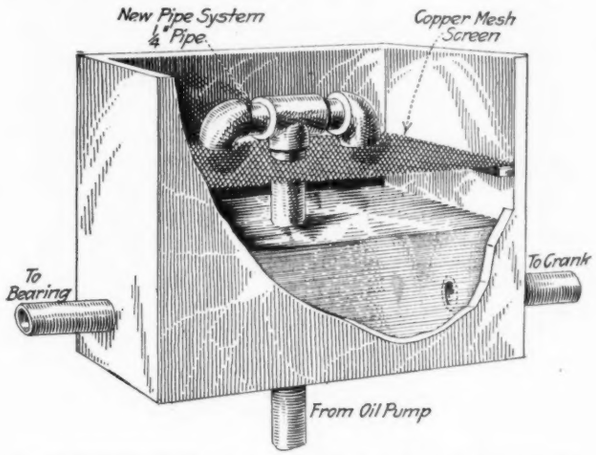
A little more than a complete revolution of the shaft, amounting to about three revolutions of the ring, was all that was necessary, and the wooden pins were then driven out and the ring put into service. A number of distorted rings were so treated, and all gave good service.

CHARLES C. LYNDE.

Pittsburgh, Penn.

Oiling-System Improvement

The regulating or distributing valves from the elevated supply tank of the self-contained engine oiling systems of our plant often became stopped up with small particles. After the oil passed through the various bearings, it



PIPE EXTENSION AND STRAINER IN OIL RESERVOIR

drained through a rather coarse strainer to the pump at the base of the engine, thence to the reservoir on the top of the engine, through a pipe entering the bottom, as shown. As the incoming oil entered with considerable force, it kept the oil in the reservoir stirred up all the time.

In order to relieve these conditions the ¼-in. pipe was extended from the bottom to the top and arranged to discharge the oil through a fine-mesh wire screen. This arrangement, in addition to removing the solid particles, gives the oil in the reservoir a chance to settle at the bottom.

R. L. HERVEY.

Washington, D. C.

Poor Plant Design Expensive

Poor judgment or ignorance exercised in the laying out or design of any part of a power plant is almost sure to prove expensive in the end. This fact was once made evident to me in a plant where I worked. In this particular instance poor design in the laying out of the 50-ft. steam main caused a shutdown of three days while a new engine part was being obtained from the factory.

The engine was a Westinghouse vertical compound. The steam line ran from the boiler to a header and from this to the engine. There were two right-angle elbows between the boiler and the header and six between the header and the engine. The steam line dropped vertically to the back of the engine and then through a right-angle elbow into the steam chest. The bleeders from the high- and low-pressure cylinders were connected together, and the pipe from them was tapped into the exhaust line. The engine was used to run two generators, connected either in parallel or run singly.

One night I started up the engine after having bled the header and cylinders thoroughly. It ran all right until I threw on the load of the generators. I was on my way back to the engine, when suddenly it began to knock and water spurted from the relief ports on the cylinders. It was shut down as quickly as possible, but not before the rocker-arm that actuated the steam valve was broken.

The accident was due to the rapid condensation of the steam, owing to the excessive number of right-angle elbows used and to the fact that the cylinders could not bleed properly because the water from the high-pressure cylinder could blow over into the lower-pressure one. The bleeder from the header was tapped in at the end about one inch above the bottom and did not drain the header properly.

W. W. PARKER.

Ames, Iowa.

Superheating Exhaust Steam

In the issue of June 20, page 885, A. Bradshaw suggests heating exhaust steam, but it is not clear just how it is to be done.

Superheating by the boiler gases will not be a simple matter, because of the large specific volume of the exhaust steam. A superheater installed under the conditions of a high-pressure superheater, at the top of the first and second passes of the boiler, would have to be three or four times the size of a regular superheater, and a glance at the cramped space will reveal the difficulties. Also the low heat conductivity of low-pressure as compared with high-pressure steam would require a further increase in heating surface. If the superheater is placed in the flue with a gas temperature of only 500 deg., there will be a low rate of heat transfer, so that to get the same superheat as if located in the usual position, a superheater of twice the surface will be required. Finally, in the ordinary industrial plant the engine units may be at a considerable distance from the boilers and the heavy investment in long lines of large exhaust mains to and from the boiler room would add to the other excessive costs and nullify the saving.

Assume that the annual investment, fixed and operating charges on a superheater alone capable of adding 110 deg. F. to exhaust steam for a 400 boiler horsepower plant are $450. Assume also 32 lb. water evaporated per boiler horsepower-hour and the total cost of steam at 15c. per 1,000,000 B.t.u. The B.t.u. in superheat = 52 per lb. of dry exhaust. B.t.u. per hour reclaimed by the superheater $= 32 \times 400 \times 52 = 665{,}600$. Dollars reclaimed per hour $= 0.15 \times \frac{665{,}600}{1{,}000{,}000} = \$0.0998$. Hours per year $= 24 \times 365 = 8{,}760$ and $\times \$0.0998 = \$874.59$ earned. Hours operation of superheater required to reclaim $\$450 = \frac{450}{0.0998} = 4{,}510$. Per cent. of total time heat must be utilized to pay for cost of superheater $= \frac{4{,}510}{8{,}760} = 52$.

The economics of the proposition is determined by local conditions, but unless the engines are located very close to the boiler room and the price of coal is high and the heat is required practically continuously, the proposition cannot be considered.

Mechanically, it is a simple problem to superheat dry exhaust steam at 5 or 10 lb. pressure up to the temperature of the live steam at 100 lb. pressure in a reheater. But it is impossible to get something for nothing. In other words, for every pound of exhaust steam so superheated, there must be a corresponding loss of available heat in the live steam used in the reheater.

It may be that in Mr. Bradshaw's plant he proposes to transmit the exhaust a considerable distance and by superheating hopes to reduce radiation loss. Superheated steam, like a gas, is more stable as regards condensation than saturated steam and has poorer heat-conducting qualities. Inclosed in pipes, it will lose less heat through pipe radiation than saturated steam at the same temperature. But it is certain that superheating the steam to 110 deg. hotter than the saturated exhaust will not produce economy in this direction. A good 85 per cent. magnesia covering will keep in all but 10 or 15 per cent. of the heat that would be radiated with bare pipes and saturated steam, and except in a transmission system of unusual length, the saving in radiation due to superheat with lagged pipes would be insignificant.

It is therefore assumed that the idea of superheating the exhaust is to use it for heating at a temperature higher than the temperature of dry steam at 5 or 10 lb. pressure. However, just as soon as this superheated steam begins to give up heat in the heating process, the superheat will be withdrawn in proportion to the amount of heating done, and it requires the utilization of only a small proportion of the total heat in the superheated steam to lower its temperature to that of saturated steam. As a heating proposition there is practically nothing in superheating exhaust.

The following data and computations illustrate the point:

Assume moisture to be eliminated from the exhaust by means of separators and traps.

Pressure of live steam = 100 lb.
Pressure of exhaust steam = 5 lb.
Temperature of live steam dry = 338 deg. F.
Temperature of exhaust steam dry = 228 deg. F.
Temperature of exhaust steam superheated = 338 deg. F.

From Marks & Davis Steam Tables:

Total heat in 1 lb. dry exhaust = 1,156.2 B.t.u.
Total heat in 1 lb. superheated exhaust = 1,208.2 B.t.u.
Total heat in 1 lb. added by superheat = 52.0 B.t.u.
Per cent. total heat in 1 lb. dry exhaust added by superheat = 4.5 per cent.
Per cent. total heat in 1 lb. superheated exhaust added by superheat = 4.3 per cent.

This means that at a considerable investment for a reheater, only 4.5 per cent. of the heat could be added to the exhaust steam, and this only at a corresponding loss in heat taken from the live steam. Also, by the time 4.3 per cent. of the heat in this exhaust steam had been utilized in heating, the temperature of the exhaust steam would have dropped to 228 deg., or the temperature of the exhaust before being superheated.

If only 1 per cent. of the heat of the superheated exhaust had been utilized in heating, the total heat per pound of exhaust steam rejected would equal 1,208.2—12.1 = 1,196.1 B.t.u. This would correspond to a superheat of 84.3 or a temperature of 228 + 84.3 = 312.3. That is, the temperature of the exhaust would drop 26 deg. with the utilization of only 1 per cent. of the heat.

The real advantage in using exhaust steam for heating is that most of the heat in steam is latent heat, which can be abstracted by condensing the steam without lowering the temperature. This heat is partly available for mechanical power, but almost totally available for heating purposes. That is, latent heat in 1 lb. dry steam at 228 deg. = 960 B.t.u.; heat in 1 lb. water at 228 deg. = 196.2 B.t.u.; and the per cent. of total heat that can be abstracted from dry steam at 5 lb. pressure for heating without lowering its temperature = $\frac{960}{1,156.2} = 83$.

If the drip must be lost for any reason such as oil pollution or cost of return, the per cent. of the total heat in dry exhaust at 5 lb. pressure lost = 17. In proportion to the value of the latent heat, which can be abstracted without lowering the temperature of the steam, the superheat = $\frac{45}{83}$, or only 5.4 per cent.

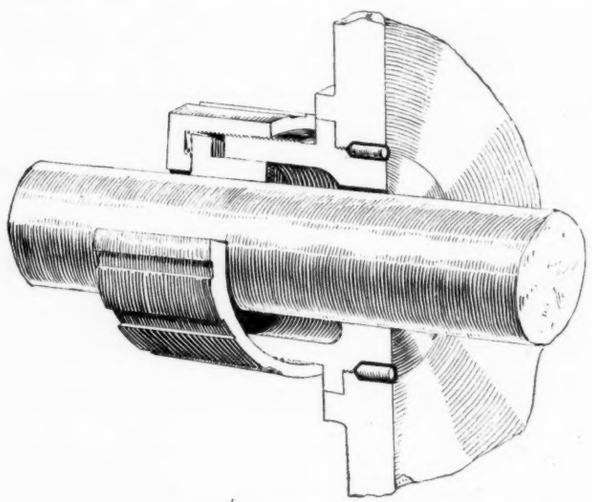
It is true that a turbine operating with superheated steam will have greater efficiency than when operating with saturated steam, both in the theoretical cycle and the practical application, but the principal saving is due to lessened condensation and friction losses, whether in a high- or a low-pressure turbine.

Brooklyn, N. Y. HAYLETT O'NEILL.

Key for Stuffing-Box Body

Small stuffing-boxes that screw into the cylinder are made secure by many different methods. Some are fastened by riveting, but it is difficult to get them out if necessary.

The illustration shows a quick and simple way of securing the box, and there is no danger of the key getting out into the clearance space between the piston and the head.



PINS PREVENT BODY FROM UNSCREWING

The keyhole is drilled, as is customary, half in the box and half in the metal of the head. A pin or key driven in is of such a size that it is a firm driving fit in the hole, but it is of such a length that it can be driven with a punch about $\frac{1}{16}$ in. below the surface of the box and head. This permits a good portion of the two to be peened over, partly closing the hole at the end of the pin to hold it firmly in place.

I have set boxes in this manner in many stationary and portable air compressors, of which service records were carefully kept, and not a single case of a loose box is registered against this manner of locking them in place.

Missouri Valley, Iowa. F. W. BENTLEY, JR.

Wetting Coal To Reduce Waste

In the issue of Aug. 1, page 177, I read with interest the letter by Mr. McGillivray on wetting coal before it enters the stokers, particularly as I have heard it discussed quite frequently and have read technical papers by combustion experts. I believe that nine out of every ten are of the opinion that any water put on the coal immediately before it enters the furnace is the waste of as many B.t.u. as is required to transform the water into vapor, which passes out with the gases to the stack.

It is evident Mr. McGillivray introduces a small evil to avoid greater ones. Theoretically it seems axiomatic that the water put on the coal must be vaporized at the expense of so many B.t.u. that are utterly lost in so far as the generation of steam in the boiler is concerned. In a certain modern plant carrying both a railway and a commercial load, Indiana screenings from the fourth, fifth and sixth veins (mostly of the latter two veins) are used on chain-grate stokers. The demand for three-minute to half-hour periods are comparatively high at certain times of the day, while the commercial load is fairly uniform, but the plant must be prepared to carry comparatively high peaks without advance notice.

With this load and with coal averaging about 10,400 B.t.u., good results are obtained by wetting the coal thoroughly as it drops into the stoker magazines by having a perforated pipe running parallel to and about two feet above them. Whenever the chute valve is opened to supply coal, the water is turned on and the coal is made so wet that the water drips from it up to the time it passes under the furnace gate. These boilers carry from 150 to 175 per cent. rating regularly and during peak periods often go to 225 per cent. The ignition is all that could be desired, the furnace efficiency is good, and the CO_2 under all conditions runs from 12 to 14.5 per cent. The evaporation compares favorably with the best in the country, as I know by comparison. Although this method of firing is condemned in theory, the "proof of the pudding is in the eating." C. A. Morris.

Michigan City, Ind.

Mr. McGillivray's letter opens up a subject that is of interest in several ways, for wetting coal is practically a universal practice. In the small power plant it is common to see a man standing hose in hand, wetting the coal before it is thrown into the furnace; and in the large central station the same thing is done only in a different way—carloads are wetted at one time.

As a matter of curiosity I have asked engineers, when visiting numerous plants, why they water their coal. Many say they do not know; some say that since water contains hydrogen and oxygen the coal takes the oxygen from the water and liberates the hydrogen, which is burnt in the furnace; others say that the coal burns better.

A little consideration will show that watering results in a decrease in the heating value of coal, as the amount of heat required to separate the hydrogen of the water from the oxygen with which it is combined is exactly the same amount that must be obtained by the complete combustion of the hydrogen in the furnace. If any of the hydrogen is liberated unburned up the stack, which is quite probable, there will be a loss of heat instead of a gain. But irrespective of the heat loss due to the possible escape of unburned hydrogen, there is a further loss. When hydrogen is burned it is transformed into water vapor and thus passes up the chimney in the form of steam. It takes heat to convert water into steam at atmospheric pressure and then superheat this steam to a temperature corresponding to that of the flue gases.

The practice does not improve the heating value. Therefore, why is coal watered? Moisture is deleterious to coal; it lowers the thermal efficiency of the furnace and may cause corrosion troubles with the assistance of soot upon metallic surfaces. Many specifications for coal stipulate the maximum percentage of moisture permitted, because of its lower heating value and increased haulage charges.

Coal is wetted, as explained by Mr. McGillivray, because the physical advantages are greater than the chemical disadvantages. When coal is dampened the very small lumps and dust particles tend to cling together instead of being blown around, falling through grates and hoppers or being blown up the chimney unburned, where forced draft and high air velocities are in use. Holes in the fire are prevented, resulting in better combustion, and less coal is wasted in the ashpit. Some claim that dampened coal has less tendency to clinker; and when clinker forms, it is softer and less troublesome to remove. Accordingly, coal is wetted, not for chemical, but for physical reasons. R. K. Long.

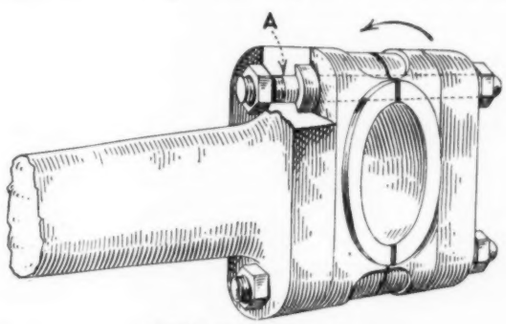
Chicago, Ill.

What Caused the Wreck?

A duplex double-acting power pump in which the writer is interested has recently broken down in a manner that is mystifying.

The pump is driven by a belt and gearing at a speed of 50 r.p.m. The crank radius is 12 in.; the crankpins are 6½ in. diameter and 4½ in. long (center cranks). The wristpins are 3¾ in. diameter and 4½ in. long. The pressure carried is such that the total maximum load on the crank and wristpins is 24,000 lb.

The crankpin boxes are babbitted, and the wristpin boxes are of bronze. The connecting-rod is of the marine type and 50 in. long. On inspection after the breakdown occurred the T-end of the connecting-rod was found to have become detached from the crankpin boxes by the breakage of the two bolts connecting the boxes to the rod. The loose end of the rod had knocked a big hole in the end of the frame, and the rod was slightly bent.



BOLT BROKE AT A

One of the two studs fastening the lower crankpin boxes to the connecting-rod end apparently let go first, the break being at the junction of the plain and threaded part of the bolt and just inside the T-head of the connecting-rod. The bolt hole in the T-end was not threaded,

but was recessed, and the bolt was passed through and held between a collar turned on it and a nut. The location of the break in this bolt is shown at *A*. This 1¾-in. machine-steel bolt was apparently pulled squarely in two, and the remaining bolt then bent until it broke in about the same place as the first one.

The wristpin, the crankpin and the connecting-rod boxes were badly scored, the wristpin end being the worst. The fractured surfaces show good material without flaws.

Can any of your readers advance a reason for this breakdown? B. P. Golder.

Leonia, N. J.

University Extension Work

In the issue of July 4, page 24, there appeared an article on the possibilities of getting instruction in engineering, as well as other subjects, through the extension division of our colleges. This fact should be emphasized. In conversations with draftsmen and machinists I have discovered that the possibilities and advantages of such an arrangement are not generally known.

It is understood, of course, that most men find a stimulus in working together and apply themselves either from pride in their ability to keep up with their class or fear of being unclassed, or they learn simply from personal contact with one another in the classroom. The instructor in a certain sense is a taskmaster or a leader and a means of overcoming the pitfalls and obstacles. The usual young fellow finds, therefore, for one reason or another, that classroom work is easier than study by himself at home, yet by reason of limited means the majority of men must take up evening-school work or get assignments and instruction by mail.

Certain subjects cannot be given except to classes, such as the laboratory courses, where expensive apparatus or machines are required, but the lecture or recitation type of work can be taken by mail with considerable success. In fact the university campus may be made to extend over every square mile of the state or country.

I would like to make clear and emphasize the advantage of the extension divisions of universities over correspondence schools conducted as business enterprises. While the correspondence-school courses are, as a rule, written by first-class engineers or teachers, the students' papers are usually corrected by clerks who have the answers to all the questions worked out for them, so that if the answer to a problem is given by the formula $\frac{\pi d^2}{4}$, then the use of πr^2 would be marked wrong. Again, frequently the student pays for a long and expensive course of which only a part is completed. A large majority I believe fail to complete the courses which they start. On the other hand, the extension division in the state universities has as its first aim the rendering of service to the people without monetary consideration. Instructors may devote all their time to extension work, or in certain courses not so popular, instructors in the regular session give part time to extension work. These instructors may write a condensed textbook in the form of assignments, or assign lessons with special instruction from a regular textbook, or give special lectures in different parts of the state. The students' papers and drawings receive more individual care in their correction than would be given to those of the regular college man.

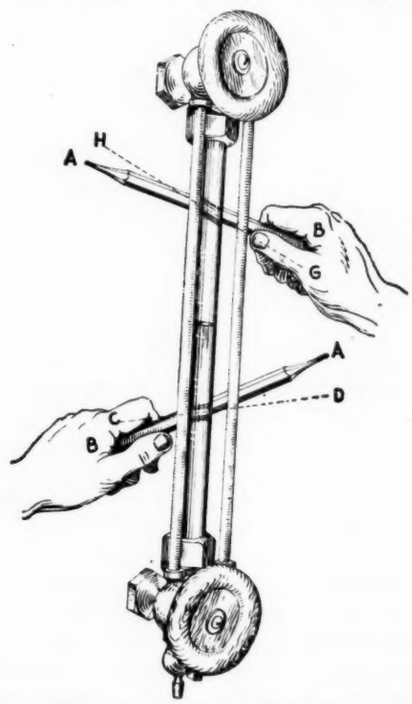
As to the cost of the work, the student is required to pay only part of the expenses of the office work and of the instructor and the state pays the remainder. It is the desire of the extension department that each student complete the course he elects, and university credit is usually given on the satisfactory completion of the course, so that a student with determination may be able to secure in this way more than 50 per cent. of the credits required for a degree.

I have at present a student who expects to get a degree in engineering by only one year of "resident study." He manages to take some evening work in laboratory courses as well as the correspondence extension work. One man completed a course in steam engineering while employed in a small power house in Alaska, and another took a course in machine design while working in a mining camp in Utah. While the instruction through correspondence is not as satisfactory as in classes, it is certainly achieving a real success. H. J. Macintire,

Assistant Professor of Mechanical Engineering,
Seattle, Wash. University of Washington.

Is the Gage Full or Empty?

A handy way to determine whether a gage-glass is full or empty is to hold a bright-colored lead pencil behind the glass between the eye and the light. If the glass is full, that portion of the pencil back of the glass will appear to take the position *CD* shown in the illustration, and if the glass is empty it will appear as *HG*.



DEFLECTION OF VISION THROUGH A LIQUID

In other words, the center line will fall below the pencil point or the line *AB* if full and above the point if empty. The amount of the deflection depends upon the condition of the glass as to oil, etc., and upon the character of the liquid in the glass. With anhydrous ammonia the deflection is very marked and the method positive and useful. By holding a white paper back of the pencil, the deflection is brought out more clearly.

Atlanta, Ga. G. A. Robertson.

Lighting-Plant Experiences

By C. V. Hull

In a small lighting plant which consisted of a 9-hp. specially designed gasoline engine for lighting work, belt-connected to a 110-volt compound dynamo, the dynamo furnished light for two store buildings, a warehouse and other smaller buildings.

Fig. 1 shows the wiring arrangement. The switches were so arranged that the buildings could be lighted by the gas-engine plant or by city current. Current for a number of offices and the post office was taken from the street circuit as indicated in the figure. When S_1 was closed and S_2 open the load on the three-wire city mains

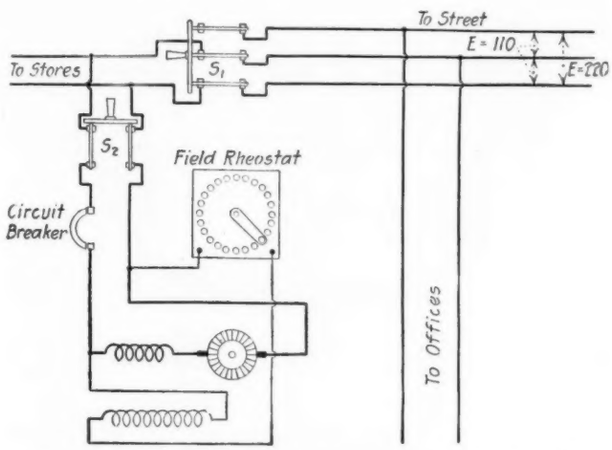


FIG. 1. SHOWS WIRING ARRANGEMENT FOR THE GENERATOR AND STREET CIRCUIT

was fairly well balanced. It would have been better if a double-pole double-throw switch had been used as shown in Fig. 2. Then there would have been no danger of getting the dynamo and the street circuit connected together.

We had a number of interesting experiences with this switch arrangement. One evening the engine seemed to be running very easy though the lights were normal. Upon investigating to see what was wrong, switches S_1 and S_2 were both found closed. The voltage of the dynamo being slightly lower than the street circuit it was therefore not taking any of the load. When S_1 was opened the engine settled down to work. Another night one of the men could not get the circuit-breaker to stay in. After a time it was found that switches S_1 and S_2 were again closed. This time the voltage of the dynamo was higher than that of the street circuit, consequently it pumped back into the street mains.

After the plant was in operation for a while troubles began to develop. The commutator used to gum so badly that the dynamo would not always generate. It was the usual thing to hold a piece of cloth soaked in gasoline against the running commutator to clean off this grease. This was very bad practice, for the cloth caught fire one night and a serious blaze was narrowly averted.

The gumming of the commutator must have been due to the oil used in the bearings. The instructions sent with the dynamo called for high-grade oil and we used sewing-machine oil. It worked out of the bearings and onto the commutator. The trouble was made worse because we were afraid we would burn out the bearings and used too much oil. I wish I knew what it cost to oil that dynamo with oil in bottles.

Flickering of the lights or rather sudden changes in the intensity of the light gave us the most trouble. At times they burned well; at others they went from red to white and back again with surprising frequency. I remember that I spent hours tracing the wiring from the blueprint which came with the dynamo. Perhaps I should not have known if something was wrong. Every brush and brush holder was removed and thoroughly cleaned. But the variation in the lights still continued and was very annoying.

Then a more experienced man helped me, who suggested that we take the governor apart. Every piece was cleaned and polished and each part seemed to fit perfectly. Yet the results were nil and new parts were ordered and put on the governor. The results were no better than before.

Finally after a number of weeks of fussing we tightened the drive belt and this remedied the trouble. Since that time I have seen plenty of trouble from loose belts.

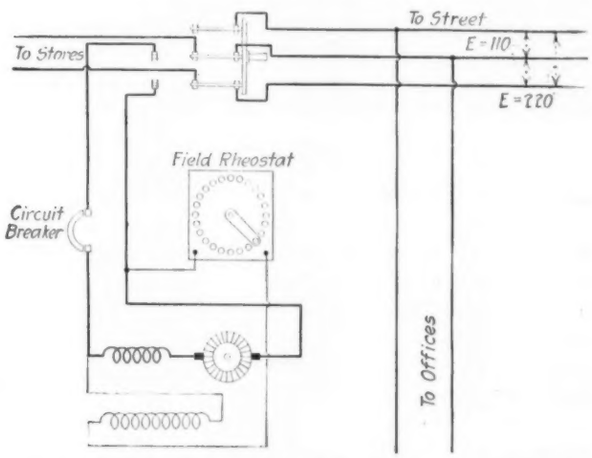


FIG. 2. SHOWS THE CORRECT WIRING ARRANGEMENT FOR THE GENERATOR AND STREET CIRCUIT

In this case I think the oil which worked from the main bearing of the engine to the fly-wheel rim and from the dynamo bearing to the pulley surface had something to do with the slipping. After the belt was tightened as it should be the engine and dynamo required but little attention.

Feeding Boilers Cold Water

By J. Lewis

There seems to be entirely too much stress placed upon the alleged injurious effect produced by feeding boilers with cold water. It is hard to believe that cold water entering a boiler well below the water line, and diffused as it must be on entering the body of the hot water in rapid circulation in the boiler, can possibly produce the injurious effects we read about—much less if sprayed into the steam space. Take, for example, a locomotive-type boiler with its feed pipe entering well to the front and below the water line. The low-temperature entering water would be thoroughly mixed with the water already in the boiler before it had traversed any considerable distance within the boiler. Granting that it does reach and affect the first tube or pair of tubes directly opposite

the entrance, the distance lengthwise affected certainly cannot be very great, so that applying the coefficient of expansion and the extreme range in temperature, the movement or shortening of the tube cannot be enough to affect it seriously.

The foregoing contemplates a sudden change in temperature, but if the cold feed water enters continuously, there will be no change in the tube temperature when once established, therefore there can be no possible evil results. The change in temperature inside of a fire tube or outside of a water tube is vastly greater when the furnace door is left open with a strong draft than can possibly be caused by cold feed water. The temperature within the firebox of a locomotive-type boiler, upward of 2,000 deg. F. during the time the fire is in its best condition, may be lowered several hundred degrees in a few moments, so that the range of temperature on the fire side is more extreme than that on the water side of the tube in any case.

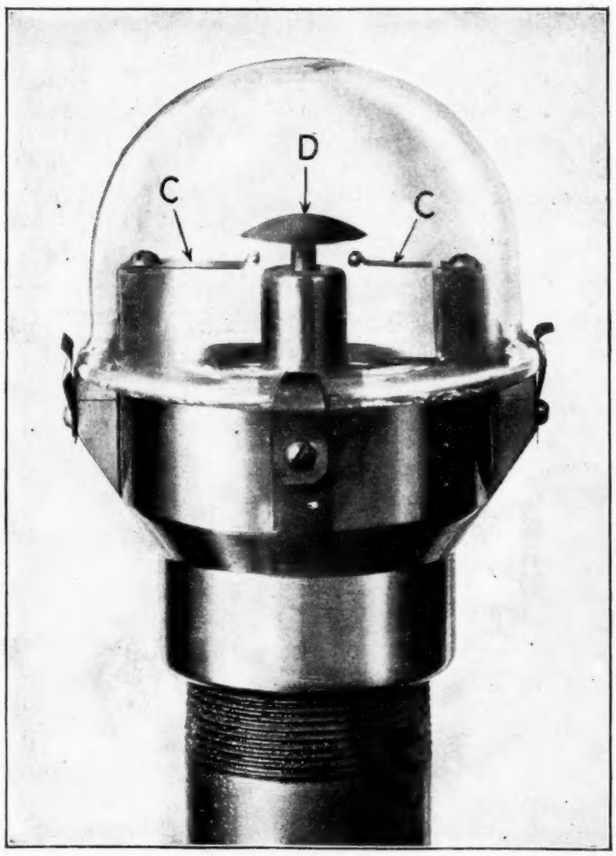
The notion that it is wrong to introduce water into a boiler when the level is abnormally low is rapidly being relegated to the limbo of mistaken notions, and along with it should go this notion of cold feed water producing disastrous effects.

Far be it from me to advocate the reckless use and abuse of boilers by allowing the water level to become low or subjecting them to extreme changes in temperature in any manner, but if a young man is told that if the water becomes low the boiler is sure to explode or that if cold water is sent in it is going to do a lot of damage, when we know that sooner or later he will do as we have all done and find out that these things do not often occur, he is apt to lose confidence in what is told him in the future. In fact, if called upon to explode a boiler with "neatness and dispatch" I hardly know how I would proceed to do it without employing the drastic expedient of fastening down the safety valve and building up a good hot fire so as to produce excessive pressure. It is fortunate indeed that boilers do not explode every time the water is allowed to get below the normal level and is pumped up again, or misbehave at every change in the temperature of the feed water. If they did, I fear the boiler maker would be the busiest man in the land, provided there were enough engineers left to use the boilers he could produce by working overtime. My practice is to exercise diligence to keep the water in sight always, but if lost, get it back into sight as quickly as possible. This is written in the hope of starting a wholesome and profitable discussion.

A Unique Air-Pressure Relay

By Frank C. Perkins

In view of the importance of positively maintaining the forced-air circulation in air-cooled transformers, it is advisable to provide all transformers with indicators arranged to operate an audible alarm to notify operators of failure of air supply. A pressure relay for this purpose is shown in the illustration. It will be seen that this device consists of a cup-shaped metal base, so arranged as to provide for the free movement and support of a ground aluminum valve plate, which carries a post supporting a contact disk *D*. The lower part of the metal base is arranged for screwing on a 2-in. iron pipe. This pipe is used for the purpose of connecting the relay with the air chamber. The two contact points *C* are arranged on the top of the casing, so that the disk, which is fastened to the valve post, will drop on them and close the circuit when the pressure in the air chamber drops below a safe operating point. The contact points are protected by an oval glass cover as shown.



AIR-PRESSURE RELAY

It may be stated that the operation of the device is such that the aluminum valve will rise and remain closed when any pressure over approximately one-half ounce is delivered in the air chamber. There is no leakage of air by the valve after it has been closed, therefore, it can be used on any pressure that may be necessary for any number or size of air-blast transformers. This device is simple in construction and on this account is suitable for installing on any form of air-blast compartments. It can be placed in an inconspicuous position and requires no large amount of space.

Thermit Is a Mixture of powdered aluminum and magnetic oxide of iron (Fe_2O_4). It is used for welding iron and for other purposes requiring the production of intense local heat. When the mixture is ignited, the oxide of iron oxidizes the aluminum, being itself reduced to free iron. This process is accompanied by an intense development of heat, the temperature rising to about 3,000 deg. C. If it is desired to weld the ends of two railroad rails together, they are placed in contact with each other and in the position required; then a sufficient quantity of thermit is placed around the joint and ignited by setting fire to a small heap of the mixture of aluminum and barium oxide placed on top of it. The temperature generated is high enough to partly melt the ends of the rails, and by pressing them together a strong welded joint is obtained.

Inquiries of General Interest

D Valve with Neither Lap nor Lead—If the D slide valve of an engine has neither lap nor lead, what should be the relative positions of the crank and the eccentric? E. B. G.

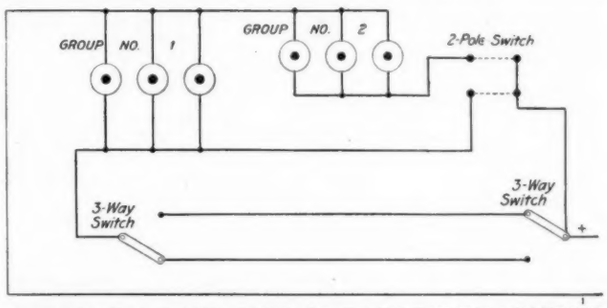
To take steam at the beginning of the stroke of the piston the eccentric would need to be at an angle of 90 deg. with the crank.

Right and Left Sides of Cross-Compound Engine—Which is the right and which the left side of a horizontal cross-compound engine? J. A. L.

When the observer stands midway between the cylinders facing the middle of the shaft, the cylinder and parts on his right are designated the right side and the parts on the left the left side of the engine.

Lighting-Circuit Control—How may three lamps in a group of six be controlled from two three-way switches, and the six lamps from a double-pole switch? J. R.

With the scheme of connections shown in the sketch, if the lamps are put on from the double-pole switch they



WIRING FOR LAMP CONTROL FROM THREE STATIONS

must be put out from the same point; otherwise the lamps in group No. 1 may be controlled from either of the three-way switches.

Good or Bad Feed Water—How much of scale-forming impurities may be contained in a boiler feed water to be called good or bad? R. W.

The designation depends largely upon what the impurities are. Containing per gallon less than 8 grains of incrusting materials like carbonate of lime, carbonate of magnesia, sulphate of lime, or chloride of magnesia, the water would be called good; 8 to 15 grains, fair; 15 to 20 grains, poor; 20 to 30 grains, bad; and 30 to 40 grains, very bad.

Counterbores for Steam Cylinders of Duplex Pumps—Why are not the steam cylinders of duplex pumps counterbored to prevent the pistons from wearing shoulders at the ends of the cylinders? D. S.

In the operation of a duplex steam pump there are no fixed positions for the pistons at the ends of the strokes; therefore counterboring to prevent wearing of shoulders in the cylinders would be of no advantage, as the piston rings would not always run over the edges of the counterbores.

Combined Efficiency of Engine and Generator—What percentage of indicated power developed by a 200-kw. direct-current engine is realized as electrical output? H. T. C.

The percentage of electrical output realized would depend on the mechanical efficiency of the engine and the commercial efficiency of the generator. Assuming the mechanical efficiency of the engine to be 90 per cent. and the commercial efficiency of the generator 93 per cent., there would be 0.90 × 0.93, or 83.7 per cent., of the indicated power realized as electrical output of the generator.

Firing in Compressed-Air Systems—What causes firing of compressed air? J. C. A.

The compressed air is not inflammable, but when compressed by piston compressors it is necessary to use oil for cylinder lubrication; and this oil, or the gases from it, forms with the air a combustible mixture that becomes ignited from the high temperature resulting from the work of compression. Firing may be due to the use of a cylinder oil of too low flash point and in some cases is caused by use of too much oil.

Diameter of Boiler Tubes—What size of tubes should be used in a horizontal return-tubular boiler 72 in. diameter by 18 ft. long, employing natural draft? R. M. D.

A common rule for the size of tubes, when natural draft is used, is to allow 1 in. of nominal or outside tube diameter to 4 ft. of tube length, for burning bituminous coal, and 1 in. of nominal diameter of tube to 5 ft. of tube length when anthracite is used as fuel. Hence with tubes 18 ft. long for burning bituminous coal the rule would call for 4½ diameter tubes; and for use of anthracite, 3.6- or nominally 3½-in.

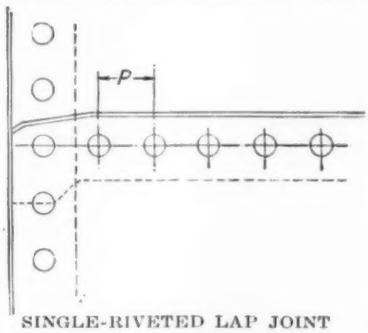
Compression of Duplex Pump—How is compression obtained in a duplex steam pump? R. C. M.

Each end of the cylinder is provided with a steam and an exhaust passage separately controlled by the steam and exhaust edges of the valve, and the opening of the exhaust passage into the cylinder is far enough from the end of the cylinder to be covered by the piston before completion of the stroke. When this occurs, with connections to the steam passage closed, and a tight fitting piston, whatever quantity of exhaust steam there may be in the cylinder or steam passage is compressed by the piston during the remainder of the stroke.

Efficiency of Single-Riveted Lap Joint—What would be the efficiency of a single-riveted lap seam, $\frac{5}{16}$-in. plate, $\frac{11}{16}$-in. rivet holes, 1⅝-in. pitch, allowing 55,000 lb. tensile strength of the plate and 44,000 lb. shearing strength for the rivets? R. N.

With a thickness of plate of $\frac{5}{16}$ = 0.3125 in., pitch of rivets 1⅝ = 1.625 in., and tensile strength of plate = 55,000 lb. per sq.in. of cross-sectional area, the strength of solid plate per unit of pitch (P in the sketch) would be

(A) 1.625 × 0.3125 × 55,000 = 27,930



SINGLE-RIVETED LAP JOINT

The strength of the joint would depend on the strength of plate between the rivets, or the shearing strength of the rivets, or the resistance which the plate offers to the crushing action of the rivets. Having rivet holes $\frac{11}{16}$ or 0.6875 in. and pitch of rivets 1.625, the square inches of cross-sectional area of plate between rivet holes would be (1.625 — 0.6875) × 0.3125; and per unit of pitch, the strength of plate between rivet holes would be

(B) (1.625 — 0.6875) × 0.3125 × 55,000 = 16,113 lb.

The strength of rivets per unit of pitch would depend on the shearing strength of one rivet in single shear. Allowing a shearing strength of 44,000 lb. per sq.in. of cross-sectional area, as the cross-sectional area of a rivet $\frac{11}{16}$ or 0.6875 in. diameter would be (0.6875 × 0.6875) × 0.7854 = 0.37122 sq.in., the shearing strength of the rivets per unit of pitch would be

(C) 44,000 × 0.37122 = 16,334

The crushing action of the rivets per unit of pitch would come from one rivet; and allowing a crushing strength of plate of 95,000 lb. per sq.in., the crushing strength of plate in front of one rivet would be

0.6875 × 0.3125 × 95,000 = 20,410 lb.

As the strength of the joint per unit of length would depend on (B), the strength of plate between rivet holes, the efficiency of the joint, as compared with the solid plate, would be

$$\frac{(B)}{(A)} = \frac{16,113}{27,930} \text{ or } 57.69 \text{ per cent.}$$

Convention of the Ohio Boil

At the invitation of the Ohio Board of Boiler Rules, inspectors and others interested in the inspection of steam boilers to the number of upward of one hundred met at the State House, Columbus, to discuss boiler legislation and its administration on Thursday and Friday, Aug. 17 and 18.

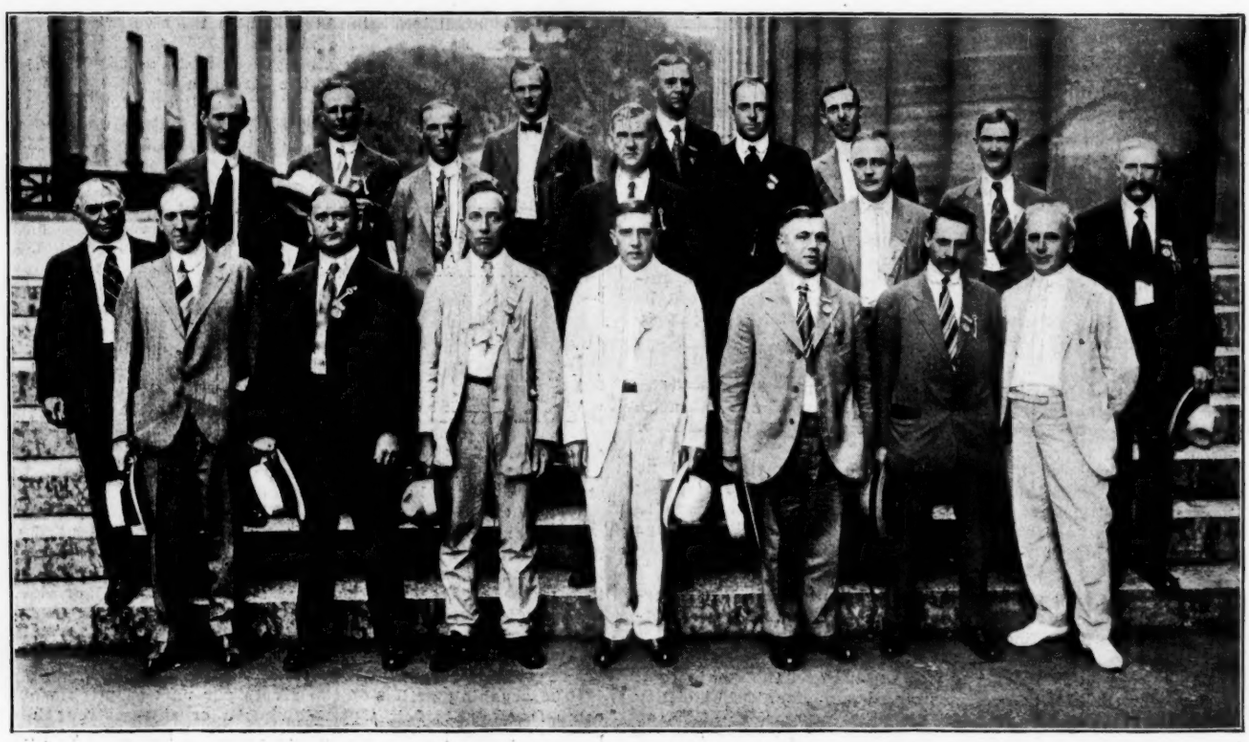
The first session was called to order promptly at 10 o'clock on Thursday forenoon by J. C. Callery, chief deputy of the division of boiler inspection of the Industrial Commission of Ohio, who in the course of his introductory remarks read a letter from D. M. Metcalf, chief of the boiler inspection department of the Province of Ontario, explaining that his failure to be present was due to his attendance upon a meeting of the Canadian Society of Civil Engineers, which had undertaken to unify the boiler codes of Canada as the American Society of Mechanical Engineers was doing for the States, and to which he had been elected an honorary member.

The convention was welcomed by Hon. Wallace D. Yaple, chairman of the Industrial Commission of Ohio, who said that the invention of the steam engine had had a greater influence upon industry and civilization than any other factor. The products of the farm and mine and forest are procured, manufactured and transported by its means. The steam engine and the steam boiler must be operated by men who have the necessary technical knowledge. Ohio had recognized this and had established bureaus for the inspection of boilers and the examination and licensing of engineers, which two bureaus were in 1913 merged into and made a part of the Industrial Commission of Ohio.

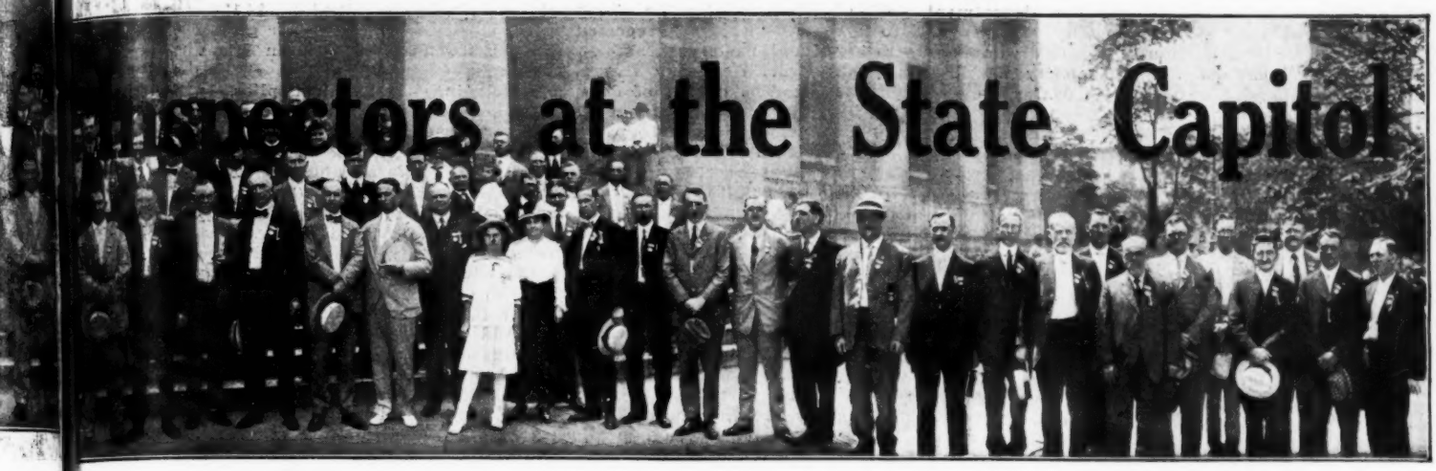
The necessity of boiler inspection is greater today than ever before, not because we are not making better boilers, but because the workingmen's compensation act has made the employer responsible for accidents, and employers everywhere are using their best efforts toward safety. The commission of which Mr. Yaple is the head has the authority to adopt, promulgate and enforce rules for safety. Under our form of government the method of regulation is a matter for each state to consider for itself, but it is a matter of the greatest importance that the regulations of the different states do not differ in important particulars. He suggested that there should be a conference between the authorities of various states and municipalities having or contemplating such legislation in the interest of uniformity, and it developed later that the advisory board to the commission has made the initial move toward calling such a conference.

Governor Frank B. Willis, who was expected to address the convention, was unable to be present at the opening session, but came in on Friday morning. Hon. H. L. Eliot, member of the Industrial Commission, who was also upon the morning's program, was prevented by sickness from attending.

Hon. Percy Tetlow, organizer for the United Mine Workers of America, said that by our methods of mining 40 per cent. of the coal was wasted while in Europe 90 per cent. was



THE OHIO BOARD OF BOILER RULES AND ITS INSPECTORS



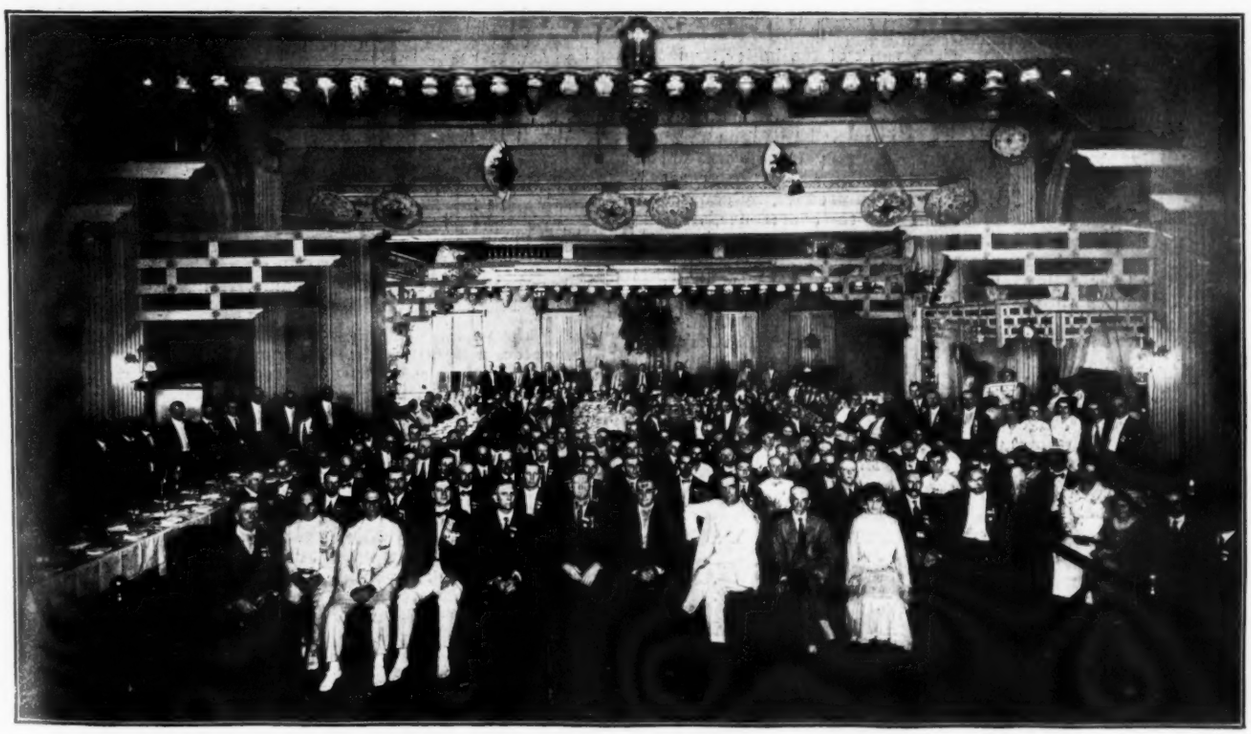
rescued. The average death rate in the industry in America is almost 4 per thousand annually while in Europe it ranges from less than 1 in Belgium to 2.04 in Prussia. The difference is due to lack of discipline in the mines and lack of enforcement of legislation.

H. A. Baumhart, vice-chairman of the Ohio Board of Boiler Rules, read a paper on the "History and Progress of Boiler Legislation." The Federal Government in 1838 passed an act formulating rules governing the inspection of steam vessels carrying passengers. In 1852 this law was amended to include freight steamers. At the sixth annual meeting of the Board of Supervising Inspectors in 1857 a table was presented showing that during the five years' operation of the law the number of explosions had been reduced to 7 as against 50 for the preceding five years. This law was fought by boiler owners and engineers, just as attempts at boiler legislation are opposed today.

One of the first laws affecting stationary boilers was passed by Philadelphia in 1868. In 1866 a company was organized for the inspection and insurance of steam boilers. Such inspection was resented by engineers as a reflection upon themselves.

At first the inspections were very simple, following the marine rule giving a single-riveted joint an efficiency of 56 per cent. and adding 20 per cent. if the longitudinal seam was double riveted. About 20 years ago we began to compute each joint. While the inspection of boilers rapidly extended, it carried with it the handicap of too many standards. Uniformity is the crying need of the present. There can be no successful inspection code without standardization, because our method of inspecting and our formula for computing the safe pressure must be the same in every particular.

The remaining time of the session was devoted to topical discussion. J. F. Whiteley, of the Fidelity and Casualty Co., cited the case of locomotive boilers passed by the Federal inspectors for 150 lb., but which had been acquired by an industrial company and under the higher factor of safety of the Ohio rules would be allowed but 112, which was not sufficient to make them serviceable. Mr. Baumhart explained that if the locomotives ran out upon the main lines and thus came under the supervision of the Federal authorities they were exempt from inspection by the Industrial Commission. If not, they would have to submit to the conditions of the Ohio rules. Discussion of means of reducing the clerical work done by inspectors in reporting inspections ensued, and inspectors were invited to send in written suggestions.



BANQUET OF OHIO BOILER INSPECTORS AT SOUTHERN HOTEL, COLUMBUS, AUG. 17

On Thursday afternoon Mr. Whiteley gave an entertaining and inspiring address on the "Duties of a Boiler Inspector"; F. R. Low, editor of "Power," read a paper on "The Necessity of Boiler Codes," and Thomas E. Durban, Chairman of the American Uniform Boiler Law Society, urged "The Advantages of a Uniform Boiler Inspection Code." George A. Luck, head

of the Massachusetts boiler-inspection department, told of recent work in that state, especially with regard to the inspection of air and ammonia vessels and ammonia safety valves. He emphasized the desirability of uniformity in boiler legislation and suggested a conference between the various state and other authorities.

W. C. Connelly, president of the D. Connelly Boiler Co., of Cleveland, being invited to address the convention, said that the American Society Code represented the best work of the best authorities, codified in consultation with every interest affected, and that any conference which produced still another code would be a step backward. Topical discussion brought out the question whether it was allowable to cut holes in boilers with the oxyacetylene torch for flanged openings, tubes, rivets, etc. The general opinion was that it was not, unless a large proportion of the metal around the hole was subsequently removed by cutting. A question whether heads up to one-half inch in thickness might be flanged cold, as on the McCabe machine, brought out the general opinion that they should be annealed after such treatment. S. F. Jeter, chief engineer of the Hartford Steam Boiler Inspection and Insurance Co., being appealed to, made the laconic reply that such cold flanging was "tank work," and Mr. Hannam, of the Kelly-Springfield Road Roller Co., said that the flanging should be done so as to upset the metal without cracking and that he preferred the hydraulic pressure to the spinning process. A member called attention to the fact that a crack could be concealed in a hand-flanged head where it would show in a McCabe head.

On Thursday evening a banquet was served at the Southern Hotel. W. C. Connelly served as toastmaster; Hon. T. J. Duffy, member of the Industrial Commission of Ohio, and W. E. Haswell, first chief inspector of boilers for the State of Ohio, were the principal speakers. The program was enlivened by music and vaudeville.

On Friday morning Victor T. Noonan, director of safety of the Industrial Commission of Ohio, described the efforts of the commission to guard the lives of industrial workers against the perils of their occupations and their own carelessness. Frank H. Yeager, of the Ohio Board of Boiler Rules, spoke from the standpoint of the operating engineer. P. D. Converse, legislative representative of the Ohio Brotherhood of Threshermen, spoke of the extent and importance of that industry and hoped to see threshing boilers brought within the scope of the inspection law. Frank E. Brownstead, chief examiner of stationary engineers for Ohio, spoke of the work of the two departments. Governor Frank B. Willis, who came in at this time, warmly praised the work of the boiler inspectors and evinced a live interest in and knowledge of the objects and scope of the meeting. All the speakers touched upon the desirability of uniform inspection laws and expressed the hope that the movement thus so auspiciously begun might be kept alive by further meetings. The session concluded with an exhibition of moving pictures illustrating the process of pipe manufacture from ore to finished product, by courtesy of the National Tube Co. The success of the conference, which bids fair to become an annual event, if not the precursor of joint meetings of the inspectors of all the states, is due to the efforts of the following committees:

Convention committee—J. C. Callery (chairman), W. A. Drake (treasurer), W. J. Hannam, W. C. Connelly, H. A. Baumhart; reception committee—C. J. Murdock (chairman), George H. Kittoe, H. V. Neff, F. P. Brownstead, George A. Barbee, L. B. Lentz, W. A. Colcord, Oscar Raabe, Walter Gerner, Thomas F. Synnett, Thomas R. Archer, R. J. Huddleston; ladies' reception committee—Mrs. Dora Weaver (chairman), Mrs. H. A. Baumhart, Mrs. C. J. Murdock, Mrs. C. O. Myers, Mrs. J. C. Callery, Mrs. Frank H. Yeager.

Census Bureau's Summary of Electric Industries for 1914

The summary of the results of the 1914 census of manufactures with respect to the electrical-machinery industry has been issued by the Bureau of the Census, Department of Commerce. It consists of a statement of the quantities and values of the products manufactured. The figures are preliminary and are subject to change and correction.

Reports were received from 1,121 establishments engaged in this industry with products valued at $359,412,676. At the census of 1909 there were reported 1,151 establishments, with products valued at $240,037,479. Although the total number of establishments reported in 1914 was smaller by 30 than in 1909, the number of establishments engaged primarily in this industry increased by 21 and the total value of products exceeded that in 1909 by $119,375,197, or 49.7 per cent. These statistics do not cover porcelain electrical supplies manufactured by the clay-working industries—valued at $4,130,270 in 1914, as reported by the Geological Survey—nor globes and battery jars for electrical use manufactured in glass works.

The output of dynamos, including parts and supplies, in 1914 was valued at $23,233,437, representing an increase of $6,001,633, or 34.8 per cent., over the corresponding value for 1909. The 1914 output of motors, including parts and supplies, was valued at $44,176,235, representing an increase of $12,088,753, or 37.7 per cent., over 1909. Motors made in 1914 for industrial power and for railway use numbered 417,992, had an aggregate capacity of 2,882,795 hp., and were valued at $32,286,149. The percentages of increase in number, horsepower and value as compared with 1909 were 62.5, 19.6, and 31.2, respectively.

Other products reported for 1914 were: Light and power switchboards, panel boards, and cutout cabinets, valued at $8,989,111, representing an increase of 50.5 per cent. over the corresponding value for 1909; batteries, storage and primary, and parts and supplies, $23,402,455, an increase of 120.5 per cent.; incandescent lamps, $17,350,385, an increase of 10.4 per cent.; arc lamps, searchlights, projectors and focusing lamps, $2,823,687, an increase of 6.8 per cent.; telephones, telephone switchboards and parts and supplies, $22,815,640, an increase of 60 per cent.; telegraph apparatus, including wireless, switchboards, and parts and supplies, $2,248,375, an increase of 14.9 per cent.; electric heating apparatus, including air heaters, cooking devices, flatirons and welding apparatus, $4,034,436, an increase of 106.5 per cent.; electric measuring instruments, $8,786,506, an increase of 12.6 per cent. electrical therapeutic apparatus, $2,653,098, an increase of 139.5 per cent.; insulated wires and cables, $69,505,573, an increase of 34.6 per cent.; electric conduits, underground and interior, $4,874,709, a decrease of 4.4 per cent.; magneto-ignition apparatus, spark plugs, coils, etc., $22,260,847, an increase of 265.4 per cent.; electric switches, signals, and attachments, $6,393,551, an increase of 18.9 per cent.; carbons for furnace, lighting, brushes, battery, etc., $3,602,741, an increase of 86.2 per cent.; annunciators, $263,806, an increase of 12 per cent.; electric clocks and time mechanisms, $410,774, an increase of 16.5 per cent.; and various other kinds of electric equipment, including sockets, receptacles and bases, some electric lighting fixtures, lightning arresters, fuses, circuit fittings and unclassified electric machinery, apparatus and supplies, $44,907,658, an increase of 56.3 per cent. The last item includes electric locomotives, mine and railway, of which there were reported 900, valued at $3,720,914.

The value of all products not of an electrical character, including custom work and repairing, in 1914 was $23,623,244, representing an increase of 33 per cent. as compared with 1909.

Of the 1,121 establishments reported for 1914, 234 were located in New York, 151 in Illinois, 129 in Ohio, 114 in Pennsylvania, 100 in Massachusetts, 83 in New Jersey, 46 in Connecticut, 46 in Indiana, 30 in California, 19 in Missouri, 18 in Minnesota, 17 in Rhode Island, 8 in Colorado, 7 in Maryland, 6 in New Hampshire, 5 in Iowa, 4 each in Delaware, North Carolina, Tennessee, Washington and West Virginia, 3 in Kentucky, 2 each in District of Columbia, Louisiana, Nebraska and Vermont, and 1 each in Alabama, Kansas, Oregon, South Carolina, Texas and Virginia.

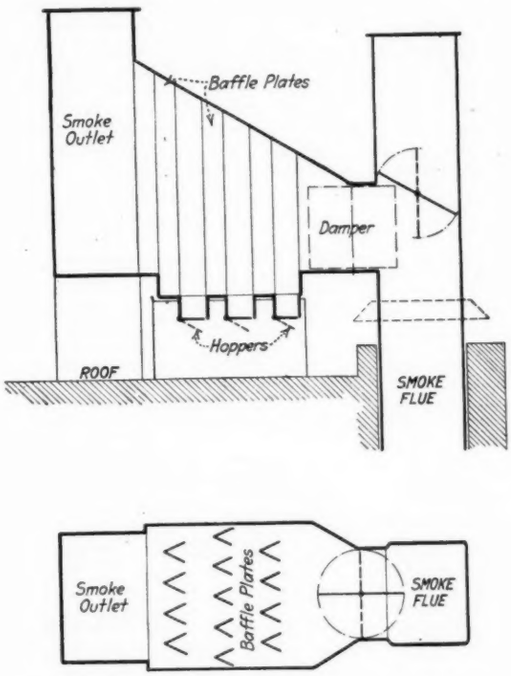
Tungsten, a Metallic Element, was discovered in 1781. For many years it was considered a waste product, but gradually its usefulness became known, and now it is used in almost innumerable ways. The discovery that tungsten could be used for incandescent-lamp filaments was not made until 1906; today, however, a very large percentage of the incandescent lamps have tungsten filaments. Probably those not familiar with this subject have the idea that the incandescent-lamp business creates the greatest demand for this metal. The amount used for electric light purposes is a very small proportion of the total, the steel industry providing the greatest demand. What is known as high-speed tool steel contains as high as 20 per cent. tungsten. This steel is moderately hard, very tough and self-hardening. Ductile tungsten can be drawn into wire 0.0002 in. diameter. It is capable of standing high temperatures, melting at about 5,400 deg. F. The metal is very heavy, having a specific gravity of 19.12 and being about 1.7 times as heavy as lead. Tungsten ore is found in various parts of the world; the bulk of the output in the United States comes from Colorado and California.

When Two or More Blowoff Lines discharge into a main, always be sure that the blowoff valves and cocks are closed on idle boilers in which men are working or likely to work, otherwise injury or death may result when line boilers are blown down, owing to water and steam backing into the idle boiler or boilers.

Removing Dust from Smoke*

The paper describes a simple apparatus for minimizing the dust nuisance from a typical isolated plant, of which there are many hundreds in operation in every large city. It consists mainly of a large settling chamber, which is fitted with a set of baffles so arranged as to extract the maximum amount of cinders without creating an undue resistance to the flow of the gases. The general scheme of construction is shown in the plan and elevation.

The apparatus has been in successful use for several months. The cinders are removed once a week from the hoppers below the settling chamber by means of the bottom



PLAN AND ELEVATION OF DUST REMOVER

cleaning doors shown. The actual amount of cinders obtained varies greatly with the amount of coal used, as well as the percentage of ash contained in the coal. Ordinarily about 5 cu.ft. of cinders are removed weekly from the collector. This does not seem a large amount, but investigation will show that this comparatively small amount of cinders will become a nuisance. The 5 cu.ft. will cover an area of 6,000 sq.ft. with cinders 0.01 in. high in one week's time.

NEW PUBLICATIONS

ENGLISH AND AMERICAN TOOL BUILDERS—By Joseph Wickham Roe. Yale University Press, New Haven, Conn. Cloth; 6x9¼ in.; 315 pages; 57 illustrations; indexed. Price, $3.

Reviewed by Dexter S. Kimball†

The purpose of this book is to show the importance of the work and influence of the great builders of machine tools. History makes note of a few of the master minds of engineering, such as Watt and Fulton. But there are other men whose names are little known, even in the engineering fraternity. If there is inspiration in reading of Watt and Fulton, there is equal inspiration in reading of the struggles and successes of Maudslay, Nasmyth, Whitney, Brunel, Bramah and Whitworth.

The development of the machine-tool industry is essentially English and American. Professor Roe's book, therefore, begins with the story of early English tool makers, not omitting, however, to give due credit to the French and other early European inventors and builders who had wrestled with these problems. The author then traces the progress of the machine-tool industry in England up to the middle of the Nineteenth Century, when the supremacy in the art began to pass to the United States. The author's reasons for this change are interesting and instructive and offer food for reflection.

The last half of the book is devoted to the stories of American inventors and builders, principally in the machine-tool industry, but necessarily overlapping other kinds of machine production. An interesting chapter, with genealogical table, shows the profound influence that the old firm of Robbins & Lawrence, which was established in the backwoods of Vermont in 1838, has had upon this art. An equally interesting chapter tells the history of the present firm of Brown & Sharpe and of the radiating influence of its founders. Other chapters deal with the development of the machine-tool industry near Philadelphia and in the Middle West.

The entire book is well written and gives a fairly full account of the history of the art of machine-tool making without being verbose. It would seem that the book would be more complete if some mention had been given of those designers who have made contribution to the art, though they were not in the business of manufacturing machine tools. Thus the work of the late Professor Sweet, which has had a great influence on American machine design, is not mentioned, nor is the work of John Riddell at the General Electric Co. or that of George W. Dickie on the Pacific Coast, though both of these latter men have produced some remarkable and very large machine tools.

COST ACCOUNTING, THEORY AND PRACTICE. By J. Lee Nicholson, C. P. A. The Ronald Press Co., New York, 1915. Cloth; 6x9 in.; 341 pages. Price, $4.

This number of the Ronald Accounting Series has reached its second printing. The author is of J. Lee Nicholson & Co., certified public accountants, a specialist in factory costs and instructor in cost accounting at Columbia University. The announced purpose of the volume is to provide for the public accountant and cost accountant a reference book dealing in a direct manner with the practical parts of cost accounting, to present the principles and methods of cost accounting in a simple way, so that the student may be able to grasp them quickly, unhampered by dissertations on organization, efficiency and the importance of cost accounting generally, and to furnish the manufacturer with a work containing all the important practical points in connection with cost accounting, summarized and briefly explained. Power costs are treated only incidentally.

THE CHEMICAL EXAMINATION OF WATER, FUEL, FLUE GASES AND LUBRICANTS. By S. W. Parr. Published by S. W. Parr, Urbana, Ill. Size, 6x9 in.; 130 pages, illustrated. Price, $1.50.

The book is a course for engineering students as given in the Division of Applied Chemistry at the University of Illinois, where the author holds that chair. The preface states that the work as outlined in the book is the result of ten years of effort to make the most of the subjects as the engineering student must take them up.

There are two parts to the book. Part 1 is in the nature of a synopsis of the lectures given, while Part 2 is devoted to laboratory methods. To one whose work makes him acquainted with the great bulk of literature on the subjects covered by the book—literature as represented by books, society papers and technical-press articles—Professor Parr's book appeals because of the absence of considerable useless matter which so burdens the bibliography of the subjects treated.

In dealing with coal the author has confined himself to Illinois coal, but this was probably the only expedient thing to do, inasmuch as laboratory methods are much the same everywhere, and because information about the characteristics of coals of the United States has been so well treated of in Government bulletins.

INSTRUMENTS FOR RECORDING CARBON DIOXIDE IN FLUE GASES. By J. F. Barkley and S. B. Flagg. Bureau of Mines, Bulletin 91; 54 pages; 6x9 in.

Because of the large number of steam-power plants operated by the Federal Government and the number of CO_2 recorders used therein, the Bureau of Mines undertook to collect information regarding the practical application of such recorders. Articles published from time to time concerning CO_2 recorders have been mostly descriptive, giving inadequate information as to the results that could be expected from the various types of instruments in ordinary practice, and most of the tests have been of a laboratory nature.

Tests of several different types of recorders were made under service and laboratory conditions to obtain needed information. The purpose of the Bureau of Mines in publishing the results is to show the factors that may affect the accuracy of a CO_2 recorder and the manner in which a recorder should

*Abstract of paper presented by a member before the semi-annual July meeting of the American Society of Heating and Ventilating Engineers.

†Professor of machine design and construction, Sibley College, Cornell University.

be tested. Readers should note that the remarks on different recorders apply to the instruments tested and not to later instruments of the same makers. In the course of the tests the following details were determined:

1. The lag of recording changes of composition of a flowing gas.
2. The accuracy of each type of recorder.
3. The variable factors affecting the operation and accuracy of each type.
4. The repairs and renewals necessary.
5. The kind and amount of attention required.

PERSONALS

W. R. McCann has been appointed valuation engineer for the Illinois State Public Utilities Commission.

Theodore M. Dame has been appointed general manager of the Boyertown Electric Co., of Boyertown, Penn.

D. R. McNeal, formerly with the Westinghouse Machine Co. at East Pittsburgh, is now with Dravo-Doyle at Philadelphia.

F. W. Brook, formerly general manager, has been elected president of the Detroit United Railway Co., to succeed J. C. Hutchins.

Joseph Bradley Murray has been appointed assistant general manager of the Edison Electric Illuminating Co., of Brooklyn, N. Y.

Fred A. Robertson, formerly with the engineering staff of the Canada Cement Co., is now with the Ontario Hydro-electric Power Commission.

A. H. Myers has resigned as engineer for the William Russel Smith Co., of York, Penn., to take a similar position with the B. F. Goodrich Co., Akron, Ohio.

William J. Snyder, formerly with the Foster Engineering Co. as its Pittsburgh manager, is now sales manager for the Vance-Vatter Co. at Pittsburgh, Penn.

George T. Snyder, formerly chief engineer of the National Tube Co., at McKeesport, Penn., has been transferred to a similar position at the Lorain (Ohio) works of the company.

Louis E. Strothman, manager and chief engineer of the Allis-Chalmers Manufacturing Co., Milwaukee, Wis., was recently elected president of the Engineers' Society of Milwaukee.

W. I. Sturtevant, for some years connected with the Stone & Webster Engineering Corporation, of Boston, Mass., has been appointed general superintendent of the Beaumont (Tex.) Light and Power Co.

G. T. McFarland, formerly New England district engineer of the automobile-equipment division of the Westinghouse Electric and Manufacturing Co., is now manager of the Ashwell Service Stations, at Hartford, Conn.

H. B. Clingerman, formerly general superintendent of the Mobile (Ala.) Electric Co., has been appointed vice-president and general manager of the Northern Idaho & Montana Power Co., with headquarters at Tacoma, Wash.

R. E. Carlson, formerly connected with the industrial sales department of the Chicago branch of the Westinghouse Electric and Manufacturing Co., has accepted the position of vice-president and sales manager of C. A. Hoppin & Co., of Peoria, Ill.

Samuel J. Hoexter has resigned from the mechanical-engineering faculty of the University of Michigan and from the secretaryship of the Michigan Engineers' Society, to become manager of the Engineers' Society of Pennsylvania, at Philadelphia.

C. E. Greenwood, who has been connected with the commercial department of the Edison Electric Illuminating Co., of Boston, Mass., and editor of "Edison Life" for many years, has been appointed superintendent of the appliance exchange of the company, succeeding W. Graydon Stetson.

Burt H. Weston, formerly instructor in mechanical and engineering drawing and design at the David Rankin, Jr., School of Mechanical Trades, St. Louis, Mo., has severed his connection with the school and has opened an office in Dayton, Ohio, where he will conduct the business of consulting and equipment engineer.

Edmund J. Henkle, for years connected with the Russian and British Westinghouse companies, and more recently assistant to the president of the International Textbook Co., of Scranton, Penn., is now assistant general manager in charge of the engineering and sales department of the Thomson Electric Welding Co., of Lynn, Mass.

MISCELLANEOUS NEWS

The Breaking of the Engine Shaft of a direct-connected generator set in the City Hall plant of Louisville, Ky., fortunately caused only slight damage. The overhanging flywheel carried within it the governor; and when the shaft broke, near the bearing, the wheel fell to the floor, broke loose from the valve rod and rolled against the wall, about six feet away, and then fell over on the floor. No one was injured, and a few minor repairs in addition to a new shaft will make good the breakage. There seems to have been a flaw in the shaft, so that only about 4 in. of the center (of the 5-in. shaft) was good. The engine had been in service about nine years.

The Bursting of a Flywheel, 36 in. face by 15 ft. diameter, partly wrecked the sawmill of the Northland Pine Lumber Co., of Minneapolis, Minn. The accident occurred just before the crew went to work for the afternoon. The engine was not up to full speed at the time, therefore the cause of the accident is somewhat mysterious. Fragments of the wheel were hurled through the roof, and two workmen were injured.

TRADE PUBLICATIONS

Brownhoist Locomotive Cranes. The Brown Hoisting Machinery Co., Cleveland, Ohio. Catalog I. Pp. 64, 6x9 in. Illustrated.

Spraco System for Cooling Condensing Water. Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletin No. 201. Pp. 16, 6x9 in. Illustrated.

Vaughan Flow Meter. Spray Engineering Co., 93 Federal St., Boston, Mass. Folder illustrating and describing this instrument, which indicates the flow of liquids in pipes.

Krause Absorbent Filter. A. E. Krause, 345 Fairmont Ave., Jersey City, N. J. Catalog. Pp. 20, 5½x8 in. Illustrated. The catalog contains views of installations of the filters for removing rough as well as emulsified oil.

Cooling Water for Ice Plants. Spray Engineering Co., 93 Federal St., Boston, Mass. This is the title of a folder showing the spraying method of this company for cooling circulating water for ammonia or steam condensers.

Polyphase Induction Motors. Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Bulletin No. 1087A. 24 pp.; 8x10½ in.; illustrated. Describes the company's line of polyphase induction motors and some of their applications.

Overhead Carrying Devices. New Jersey Foundry and Machine Co., 90 West St., New York, N. Y. Catalog No. 88. 48 pp.; 6x9 in.; illustrated. Describes the company's varied line of hand and electric cranes, monorails, trolleys, hoists, etc.

Dean Boiler Tube Cleaner. The William B. Pierce Co., 56 North Division St., Buffalo, N. Y. Booklet. Pp. 20, 5x7 in. This booklet, entitled "The Logic of the Dean," besides describing and illustrating the Dean cleaner, discusses the scale problem in detail.

Webster Vacuum System of Steam Heating. Warren Webster & Co., Camden, N. J. Catalog. Pp. 144, 8x10 in. Besides describing the vacuum steam-heating system, the catalog also shows other appliances made by this company, including feed-water heaters, steam separators, steam traps, air-conditioning apparatus, etc.

Iron Cements, Paints, Etc. Smooth-On Manufacturing Co., 570-574 Communipaw Ave., Jersey City, N. J. Smooth-On Instruction Book No. 16. Pp. 144, 4½x6½ in. This book contains many new examples and illustrations showing the working of the different Smooth-On iron cements and should be of value to any engineer.

Belt Pulleys. This is the title of two booklets issued by the American Pulley Co., Philadelphia, Penn. One contains report of tests by H. M. Haven and William W. Crosby, engineers and architects, and the other is a reprint of a paper by Charles A. Brinley read before the Engineers' Club of Philadelphia. Both booklets contain tables and curves useful to engineers.

Wetzel Automatic Mechanical Stoker. The Wetzel Mechanical Stoker Co. of New York, Inc., 30 Church St., New York. Catalog No. 9. Pp. 54, 8x11 in. This catalog contains actual reproductions of blueprints showing detailed construction, also tables of sizes of chimneys with approximate horsepower of boilers and proximate analyses and heating values of American coals.

Typical I-T-E Circuit-Breaker Installations. The Cutter Electrical and Manufacturing Co., Nineteenth and Hamilton St., Philadelphia, Penn. Catalog. Cloth; 351 pages; 9x11 in. This catalog contains approximately 300 illustrations of switchboards and installations of circuit-breakers for the protection of electric circuits in a large number of different industrial plants. The work contains many useful data that should prove of great interest to those who have problems of the above nature to solve.